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REPORT OF THE HAWAII AGRICULTURAL EXPERIMENT STATION

1931

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Issued April, 1932

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OFFICE OF EXPERIMENT STATIONS

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HAWAII AGRICULTURAL EXPERIMENT STATION, HONOLULU

[Under the joint supervision of the Office of Experiment Stations, United States Department of Agriculture, and the University of Hawaii]

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KONA SUBSTATION

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[1] Appointment effective July 7, 1931.
[2] Appointment effective June 1, 1931.
[3] Appointment effective Nov. 5, 1930.
[4] Appointment effective Mar. 1, 1931; resigned Aug. 1, 1931.
[5] Transferred from the discontinued Waiakea substation Sept. 1, 1930.

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Washington, D. C. April, 1932

REPORT OF THE HAWAII AGRICULTURAL EXPERIMENT STATION, 1931

CONTENTS

Page
- Summary of investigations 1
- Report of the agronomy division 4
  - Pigeon peas 4
  - Green-manuring crops 4
  - Forage grasses 5
  - Root crops 5
  - Other crops 6
- Report of the animal husbandry division 7
  - Cattle 7
  - Swine 8
- Report of the chemical division 9
  - Macadamia nut 9
  - Soil investigations 10
  - Coffee 10
  - Grasses 12
  - Starches 13
  - Miscellaneous analyses 14
- Report on special avocado chemical investigations 14
  - Isolating the bitter principle 14
  - Sterol content and vitamin value of avocado oil 15
- Report of the horticultural division 17
  - Propagation of tropical fruits and nuts 17
  - Macadamia nut 19
  - Akala or native raspberry and other species of Rubus 23
  - Kona substation experiments 24
  - Arboretum 26
- Report of the nutrition laboratory of the home economics division 28
  - Vitamin content of Chinese cabbage 28
  - Vitamin content of the Hawaii shellfish opihi 28
  - Hemoglobin regeneration 29
  - Vitamin C content of Hawaii-grown oranges 29
  - Vitamin B content of rice-bran bread 30
  - Biological value of the protein of the pigeon-pea seed 30
- Report of the poultry husbandry division 30
  - Sorehead (fowl pox) control in baby chicks 30
  - Sex determination in day-old purebred chicks 31
  - Battery brooding method for chicks 31
  - Papayas, avocados, bananas, and sweetpotatoes for poultry 31
  - Raw cane sugar for baby chicks 31
  - Miscellaneous notes 31
- Report of the soil physics division 32
- Report of the Haleakala substation 32
  - General statement 32
  - Distribution of seeds and plants 33
  - Experiments at the higher elevations 33
- Report of the Kona substation 35
- Literature cited 38

SUMMARY OF INVESTIGATIONS

By J. M. Westgate, *Director*

During the year covered by this report substantial progress was made in all coordinated activities formerly carried on independently by the Federal station of the United States Department of Agriculture and by the University of Hawaii. Attention was given primarily to problems dealing with minor agricultural crops and with the animal and poultry industries. The latter are growing in importance with the continued increase in the population of the islands.

The availability at the beginning of the year of an additional appropriation of $5,000 enabled the station to make a substantial start with research of a fundamental nature. The station acquired the use of several additional tracts of land for trial plantings at different elevations and under varying climatic conditions. The work at the Waiakea substation, island of Hawaii, was discontinued, and the equipment was moved to the newly established Kona substation on the western side of the island of Hawaii. Planting operations were begun at Kona in November, 1930.

A 4.2-acre tract of land, adjoining the prisoners' camp near Olinda, island of Maui, where extensive trials with the pigeon pea were begun at an elevation of 3,500 feet, was set aside by an executive order of the governor, dated March 31, 1931, for utilization as a part of the Haleakala substation. Three additional tracts of privately owned land at still higher elevations in the same vicinity were made available for trial plantings of the pigeon pea and other forage crops.

The station, working in cooperation with the Territorial department of forestry, began a series of plantings at the higher elevations of the Territorial forest reserve on the island of Oahu. In every instance the plantings at higher altitudes gave such markedly different results in growth and behavior as to justify devoting considerable time to a study of the various trees, plants, and crops under test there.

Work in agronomy was carried on at the university farm, the Pensacola Street station, and the Haleakala substation, including the four newly acquired experimental tracts at elevations ranging from 3,500 to 6,400 feet, and the tract at the original substation near Makawao, at an elevation of 2,162 feet. In addition to the 591 different varieties, hybrids, and selections of pigeon peas that were under test at the three principal places, 366 new selections were planted. The forms giving the greatest promise of success at the higher elevations were planted along the slopes of Haleakala. These plantings included several selections from the Himalaya Mountains in India. Seed-production studies were continued with 62 different species and varieties of green-manuring crops. Study was made of the effect on seed production of different spacings of the hills in the row and of varying the number of plants in each hill. About 50 species and varieties of economic grasses were tested for use as feed for livestock and to provide a convenient source of propagating material for distribution to dairymen and others. Experiments were continued with many varieties of taro, cassava, sweetpotato, ginger, and edible canna. Plantings were also made of 10 varieties of red peppers and 12 varieties of garden beans.

Work in animal husbandry was primarily concerned with feeding experiments. The seventh year of a test undertaken to determine the effect of feeding sugarcane molasses on milk production and breeding ability in dairy cows was completed. Further study was made to learn the effect of feeding sprouted oats to dairy cows and brood sows, but definite conclusions are not yet available.

Studies of the avocado, the Macadamia nut, and pasture grasses, and fertilizer experiments with coffee, constituted important lines of work in the chemical division. The bitter principle that develops in the avocado when the fruit is heated was isolated and identified. Methods of avocado-oil extraction were further developed, and sterol was successfully isolated from the oil. Studies of the oil content of the avocado were facilitated by the use of the rapid refractometer method of determination. Macadamia nuts were found to vary widely in oil content, a fact that promises to have an important bearing on future selective-breeding work with the crop. Analytical and fertilizer studies were made with the more promising kinds of pasture grasses on several of the larger ranches. Fertilizer experiments with coffee were begun, and a preliminary coffee-soil survey was undertaken on the island of Hawaii. Miscellaneous analyses were made with a view to solving local problems dealing with fruit preservation, with gardening, and with food composition. Further studies were made of the physical and chemical properties of edible-canna starch.

The horticultural work was concerned principally with methods of propagating and maintaining plantings of tropical fruit and nut trees, and with the establishment of block plantings of the more important economic species in sufficient number to furnish propagating material for fertilizer and cultural experiments. The last line of work mentioned is being carried on preparatory to the establishment of a newly planned economic tropical arboretum by the graduate school of tropical agriculture of the University of Hawaii and the station. Special attention was given to problems dealing with Macadamia, pistachio, and cashew nut trees. Plantings of the more important tropical fruit and nut trees were made at the Kona substation, island of Hawaii, where climatic conditions are different from those at the station in Honolulu. Most of the earlier plantings were made at the latter place. Further attention was centered on the development of various species of Rubus for growth at the higher elevations.

The nutrition laboratory of the home economics division concerned itself primarily with studies of the vitamin content of Chinese cabbage (*Brassica chinensis*), Hawaii-grown oranges, rice-bran bread, and the Hawaii edible shellfish, locally known as "opihi." Some progress was made in a study of the biological value of the protein of the pigeon pea (*Cajanus indicus*). Large, healthy colonies of white rats and guinea pigs were bred for use in the nutritional investigations.

The poultry division continued its studies of the control of sorehead (fowl pox) of baby chicks, giving special attention to the "stick method" of vaccination with "live virus" vaccine. Observations were continued to discover a simple method of readily determining the sex of purebred day-old chicks. Experiments were made comparing the relative merits for chicks of fireless battery and electrically heated battery brooders. No cannibalism was noted when the canopy type of electrically heated brooder was used, but some cannibalism occurred in both the fireless and the electrically heated battery brooders. A test was begun to determine the relative nutritive value of Hawaii-grown papayas, avocados, bananas, and sweetpotatoes as a fattening feed for hens. An experiment was also begun to determine the feeding value of raw cane sugar for baby chicks.

The soil physics division confined its attention to two investigations of fundamental scientific importance. One study was concerned with the factors affecting the rate and magnitude of capillary rise of water and its movement through soils; the other dealt with the correlation of the ratios of the moisture equivalents and the wilting coefficients of a set of economically important soils and the silica sesquioxide ratios of the extracted colloids of the soils.

Over 600 different lots of pigeon peas and numerous grasses, green-manuring and root crops, berries, fruits, and vegetables were under test at the Haleakala substation. Extensive experiments were undertaken to learn the relative efficiency of certain green-manuring crops for pineapple plantations. Pineapple fruits were matured on an experimental plat near Olinda, island of Maui, where the elevation is 3,300 feet. The acclimatization and selective-breeding work with pigeon peas and other forage plants necessitated the establishment of four additional experimental tracts above the substation along the slopes of Haleakala. These tracts are located at elevations of approximately 3,500, 4,800, 5,500, and 6,400 feet. The results obtained at these altitudes will presumably be applicable to about 20,000 acres of range lands on the island of Maui and to extensive areas on the other islands of the group. Cooperation in facilitating the extension work was maintained with the agricultural extension division and with various county agents.

A noteworthy event of the year was the establishment of the Kona substation in the southwestern part of the island of Hawaii. A residence for the superintendent, water tanks, minor buildings, and roadways were constructed, and 2 acres of the 3-acre tract in which the substation is located were cleared and planted with 103 different species, varieties, or strains of economically promising tropical fruit and nut trees or plants. Most of the plantings survived the very severe drought of the year 1930. In addition to growing many plants on the tract, the substation serves as a working center from which a number of outlying experiments can be operated in cooperation with private growers of coffee, grazing grasses, and fruit and nut trees. These experiments are conducted under the general direction of the respective project leaders at the central station in Honolulu, but the substation superintendent keeps in touch with the various lines of work as occasion requires.

REPORT OF THE AGRONOMY DIVISION

By J. M. Westgate, J. S. Low, and M. Takahashi

PIGEON PEAS

Selective-breeding work with the pigeon pea (*Cajanus indicus* constituted the chief activity of the agronomy division. The 591 former plantings were kept under observation, and 366 selections were made for further test and observation, especially of their ability to succeed at the higher elevations where the ordinary forms fail to mature seed. The more promising of these selections were planted on the four new tracts at the Haleakala substation during the year.

GREEN-MANURING CROPS

The experiments on green-manuring crops carried out during the previous year were repeated. An effort was made to determine the effect, especially on yields of seed, of varying the number of plants in each hill. Plantings of the more promising green-manuring crops were made at the university farm and the Pensacola Street station. (Figs. 1, 2, and 3.) These plantings were not duplicated at the

Haleakala substation because in former experiments none of the green-manuring crops bore satisfactorily at the higher elevations.

FORAGE GRASSES

About 50 species of economic grasses are being maintained by the station at the university farm, the Pensacola Street station, or the Haleakala substation. There is a strong demand for the propagating material of these grasses for soiling, grazing, and lawn purposes. Napier or elephant grass (*Pennisetum purpureum*), Merker grass (a form of *P. purpureum*), kikuyu grass (*P. clandestinum*), and Mexican grass (*Ixophorus unisetus*) are the popular grasses. *Stenotaphrum secundatum*, locally known as "buffalo" grass, is in strong demand for lawns where the trees develop too dense a shade for the growth of the customary lawn grass (*Cynodon dactylon*), locally called "manienie."

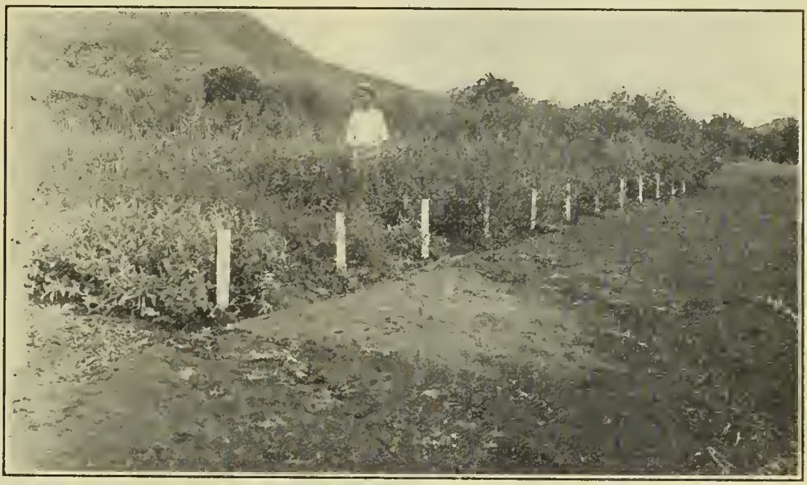

FIGURE 1.—Various species of Crotalarias used in the green-manuring seed production tests

ROOT CROPS

Nineteen varieties of Hawaii and Japanese dry-land taro (*Colocasia esculenta*), and 10 varieties of Hawaii wet-land taro were harvested. All the varieties were grown on dry land. The wetland varieties made as good a showing as did the dry-land varieties and in a few instances outyielded the latter.

Fourteen established varieties of cassava (*Manihot utilissima*) were maintained at the Pensacola Street station—largely to serve as a convenient source of propagating material for farmers desiring to grow cassava as a feed for livestock.

Over 50 kinds of sweetpotatoes (*Ipomoea batatas*), including hybrids and selections, were maintained at the Pensacola Street station. Their desirable qualities are being observed and the more promising kinds will be distributed to growers for further test.

A cultural test was made to determine the comparative yields of rootstocks from small, medium, large, and unassorted pieces of ginger (*Zinziber officinale*) seed stock. Both ordinary and Chinese varieties were used.

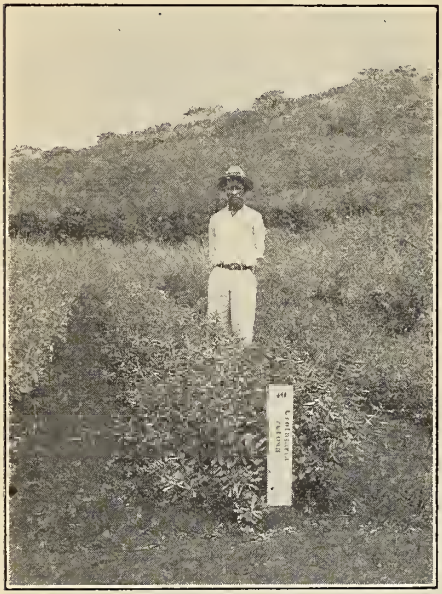

FIGURE 2.—*Crotalaria retusa* as a green-manuring crop, heavily loaded with seed

Plantings of edible canna (*Canna edulis*) were maintained at the Pensacola Street station largely to serve as a source of propagating material and also to assure a supply of the different selections and hybrids under test.

OTHER CROPS

Ten varieties of red peppers (*Capsicum annuum*) were obtained through the courtesy of L. N. Bilger, of the University of Hawaii, and planted in a variety and yield test to determine their commercial possibilities.

Tests were continued with the Kentucky Wonder bean and some of its hybrid forms that are proving to be of considerable promise for table purposes. Nine varieties of garden beans, obtained from France in 1928, are being grown for observation and for seed production.

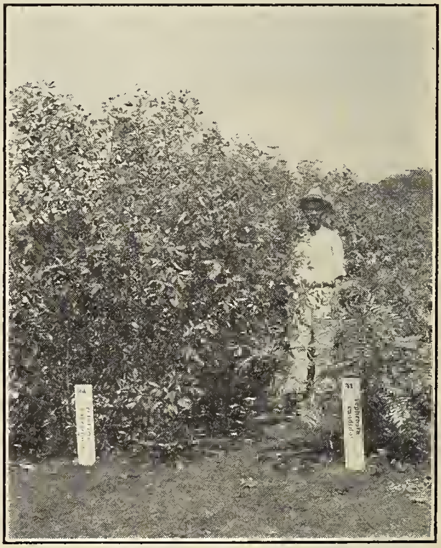

FIGURE 3.—*Crotalaria anagyroides*, a promising green-manuring crop

Of several hundred hybrid forms of lettuce previously under test, five of the most promising were planted for further selection. Four of the latter bred practically true to type. Hybrid No. 1787 is the most promising, the 250 plants showing striking uniformity in such essential characteristics as good heading qualities and freedom from bitterness.

As a basis for future fertilizer and cultural tests with coffee (*Coffea aribica*), preliminary observations are being made of the normal variations in yield of trees in a given block receiving uniform treatment. The individual variation of the trees in yield from year to year is being plotted. In some instances a tree producing 50 pounds in one year has yielded only about 10 pounds the following year. Such variation in yield from year to year in trees receiving uniform cultural treatment makes it necessary to use great care in attributing variation to differences in the fertilizers applied, or to the methods of pruning and spacing practiced. Observations were continued to determine the relative merit of planting two coffee trees instead of one of the same kind in a place system. In one instance two trees when planted together gave a combined yield of 110 pounds as compared with a yield of 80 pounds from the best individual tree grown singly in the orchard row.

Plantings of four varieties of tobacco (*Nicotiana tabacum*) were made to determine what variation occurs in the nicotine content of the leaves at different stages of maturity. (Fig. 4.) These data will be of value primarily in the contemplated preparation of an insecticide for use in pineapple fields.

FIGURE 4.—Tobacco plants used in testing the nicotine content of the leaves of different varieties

REPORT OF THE ANIMAL HUSBANDRY DIVISION

By L. A. HENKE and M. MANEKI

CATTLE

At the close of the fiscal year the dairy herd numbered, of the Holsteins, 2 bulls, 26 cows, and 16 heifers and calves; and of the Guernseys, 1 bull, 10 cows, and 8 heifers and calves.

Because only about 13 acres of land are available for grazing, soiling crops are grown on the farm and fed throughout the year as roughages to supplement the standard concentrates. The roughages are largely alfalfa, Sudan grass, sorghums, and Napier grass. The dairy herd is stabled only during the milking period, and the other animals are fed in the paddocks. The milking barn and the milk house are modern in construction and equipment. The dairy herd serves the dual purpose of providing animals for use in experiments made by the experiment station and also for instructional purposes for students at the university.

Abortion studies, including agglutination tests by the veterinary division of the board of agriculture and forestry, were continued.

FEEDING RAW ROCK PHOSPHATE

For a period of about 10 years raw rock phosphate has been fed to the dairy herd in amounts ranging from 1 to 1¼ per cent of the concentrate mixture as a protection against mineral deficiency. At no time since the feeding experiment was started have the strikingly deleterious effects noted at several of the mainland stations been observed here. The rock phosphate, a product of the South Sea Islands, contains less fluorine than does some of the rock phosphate secured in the continental United States. This fact, or the feeding of green forages throughout the year as is the local practice, may influence the results.

FEEDING A RATION CONTAINING SUGARCANE MOLASSES

Sugarcane molasses is both plentiful and cheap in Hawaii and may make a desirable feed for dairy cattle because of the relatively high cost of the imported concentrates. An experiment in which cows are fed a concentrate mixture containing 25 per cent of sugarcane molasses is now at the end of its seventh year at the station and will be continued for another year or two to obtain additional information on the effect on milk yield and reproduction. Results to date, while not complete, suggest that 25 per cent of sugarcane molasses in the ration may be somewhat too high for best results in both milk yield and breeding.

FEEDING SPROUTED OATS TO BREEDING DAIRY COWS

According to Winters (*8*),[1] the thought that sprouted oats, because of the abundance of vitamin E it contains, might be of value in overcoming temporary sterility in dairy cows, when the sterility is not due to pathological or other abnormal condition, originated with Herbert M. Evans, of the University of California. Graves (*4, p. 17*), of the Bureau of Dairy Industry of the United States Department of Agriculture, also carried on some work along this line, and others made observations (*1, p. 7*) at various commercial dairies to learn the effect of feeding sprouted oats to dairy cattle as a remedy for sterility. In the present experiment sprouted oats is fed to every alternate cow or heifer that exhibits any irregularity in breeding behavior, such as failure to show the normal oestral cycle or to conceive after being bred. The cows not otherwise under test are used as a control group. To date 18 cows and heifers have been or are being fed, and there is an equal number of animals in the control group, but it is too soon to draw definite conclusions. Results thus far, however, are not especially favorable to sprouted oats as a remedy for temporary sterility in dairy cows.

SWINE

Included in the swine herd at the close of the fiscal year were 11 Tamworth and 5 Berkshire breeding animals and 37 smaller pigs. These are used for study by men specializing in animal husbandry and for experiments undertaken by the station. The buildings used for the swine consist of one central piggery with concrete feeding pens, feed-storage room, and scale room, and there are portable hog houses in outside paddocks.

FEEDING SPROUTED OATS TO BROOD SOWS

Sprouted oats are fed at the rate of 1 pound daily, dry basis, per animal, to every sow or gilt that exhibits abnormal breeding behavior.

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[1] Italic numbers in parentheses refer to Literature Cited, p. 38.

The alternate sows not receiving sprouted oats are used as a control group. To date six sows or gilts have been, or are being fed the oats, and an equal number of animals are used as controls. The experiment has not progressed sufficiently far to justify drawing definite conclusions.

FEEDING RAW SUGAR

Palatability is an important factor in animal nutrition; and since increased consumption usually results in more economical gains in body weight, the use of raw sugar at its present low price as a means of increasing palatability seemed practical. A mixture consisting of 88 pounds of barley, 8 pounds of tankage, 2 pounds of linseed oil-cake meal, 1 pound of steamed bone meal, and 1 pound of salt was fed to the hogs in the control group. In the sugar ration 5 per cent of raw sugar was used to replace an equal weight of barley in the control ration, and in a third ration 10 per cent of raw sugar was substituted for a like amount of barley. Eighteen hogs were used in each experiment, 6 in each lot, and the experiment was replicated three times, using a total of 54 hogs. In practically all instances faster and more economical gains resulted from the addition of raw sugar to the ration.

REPORT OF THE CHEMICAL DIVISION

By J. C. Ripperton and D. W. Edwards

MACADAMIA NUT

Twelve representative 8-year-old seedling trees of the smooth-shelled variety of Macadamia nut in a local orchard were selected for study throughout the year. The nuts from each tree were accumulated for a month, at the end of which time the total weight from each tree was determined and a 2-pound sample was taken for analysis. After being allowed to dry for one month, the samples were subjected to the various methods of study developed to determine the oil content, the proportion of culls, and the cracking and roasting qualities. The largest annual yield per tree was 65 pounds of husked nuts, and the lowest 36 pounds. The kernel yield of the best tree was 40 per cent and of the poorest 21 per cent. The high oil content noted in previous experiments persisted in all the trees. Ninety-eight per cent of the nuts from the best trees contained 70 per cent or more of oil, whereas from the poorest tree 85 per cent of the nuts contained 70 per cent or more of oil. A small number of nuts fall from most Macadamia trees throughout the year, but the main crop falls during a period of about three months. The nuts falling before and after the main crop are likely to be subnormal in quality.

Work was continued on methods of grading nuts both for factory use and for planting. Improvement was made in the technic of determining the oil content of the nut by means of the refractometer and by the specific-gravity method. The latter is accurate to within plus or minus five-tenths of 1 per cent and is especially valuable for the study of individual nuts or for dividing nuts according to oil content. A score card was developed for scoring Macadamia nuts, patterned after methods used in scoring other commercial nuts. On the basis of 100, proportion of kernel is scored as 40, size of kernel as 20, packing appearance as 10, and cracking quality as 30.

One sample of nuts from each of 11 trees located in different parts of the islands was graded and scored. Extreme variation occurred in the different properties of the nuts. Under the method of scoring described above, the variation in the score ranged from 42 to 97. Bitter nuts were found on three trees. These are being investigated to learn whether the bitter principle is inherent or due to the adsorption of tannin from the husk.

SOIL INVESTIGATIONS

SURVEY OF THE KONA DISTRICT

The chemical division working in cooperation with the geologist of the Volcano Observatory, United States Geological Survey, made a soil survey of the Kona district of the island of Hawaii. This district is geologically very young. The massive rock formation has shown practically no disintegration. The soil is derived almost wholly from the scoria of a-a lava flows and from volcanic ash. The type of underlying lava and the varying amounts of ash and scoria form a logical basis for classification of the soils and division of the district into definite soil areas. Plans are under way to correlate the soil types with coffee production and fertility. It is believed that the soil map which is being prepared will be of value not only in a study of the present agriculture of the district but also in forming a basis for outlining the Kona areas of potential importance for extension of the coffee and other agricultural crops.

RELATION OF TYPE TO PARENT MATERIAL

It is a question whether the lava types of the Hawaiian Islands are sufficiently different to give rise to differences in soil type, especially on the older islands of the group where many of the soils are approaching the lateritic stage. There is, however, a very pronounced difference in the nature of the soils derived from volcanic ash and from lava. The former have received little study because of their occurrence largely on the upper mountain slopes. During the year a series of soil samples for analyses were collected from the principal ash areas of the island of Hawaii. Preliminary analyses showed great differences in physical properties, particularly with respect to hydration. Certain of the highly hydrated types when air-dried could not be dispersed even on prolonged shaking and stirring. Samples of these soils should be taken moist and preserved in air-tight containers. It is planned to continue the study of the physical and chemical characteristics of these ash soils.

COFFEE

REJUVENATION OF OLD PLANTINGS

Experiments, begun in 1929, to determine the best method of renewing old coffee plantings in the Hamakua region, island of Hawaii, were continued. Each plant receives the standard amount of complete fertilizer in October, one application of sodium nitrate in January and another in March. The heavily pruned and the thinned plats show excellent new growth. (Fig. 5.) Unfortunately much pruning is required to thin out the excess of new growth. New uprights have developed on practically all the trees of which the trunks were cut off 1 foot above ground to induce new top growth. The growth of seedlings has been somewhat retarded by dry weather during their first year.

FERTILIZER EXPERIMENTS IN KONA

Two fertilizer experiments with coffee were begun during the year, one in the Kainaliu region and the other in the Kealakekua region. The plantings are 4 and 6 years old, respectively, and are set in 50 plats (25 at each place) of 9 trees each, spaced 9 by 9 feet.

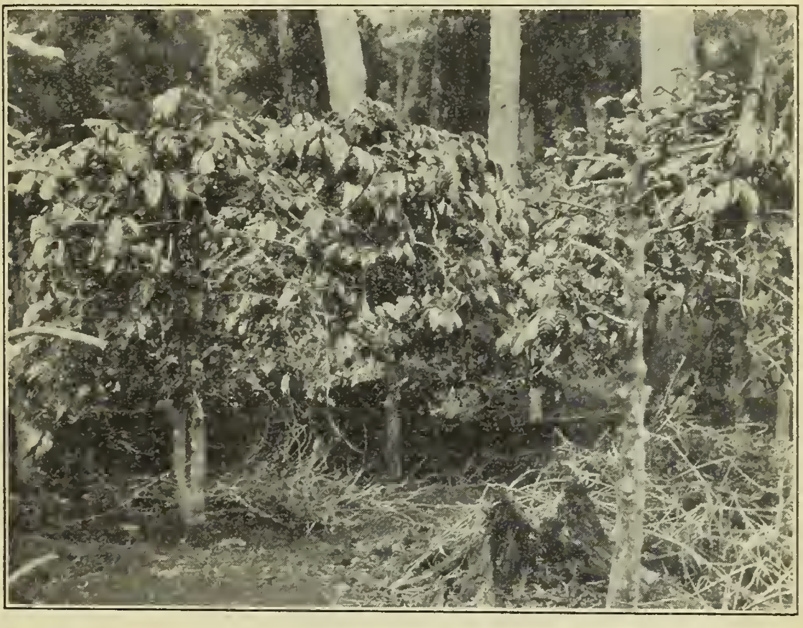

FIGURE 5.—Rejuvenation of coffee plantings 20 years old. Severely pruned plants showing the vigorous new lateral growth six months later

Field experiments with coffee in the Kona district present unusual difficulties in soil, topography, and plant. (Fig. 6.) Under the type of pruning practiced in Kona the trees, particularly the younger ones, are in different stages of development each year. The experiment in Kealakekua is designed primarily to permit study of the effect of these factors on the magnitude of the annual and the interplat variation. All trees in the experiment are receiving uniform fertilizer and cultural treatment. Growth notes are being taken semiannually to correlate variation in yield with growth characteristics. The yield of coffee cherries per plat is being determined. It is planned to continue using the uniform fertilizer treatment until such time as a definite yield value can be assigned to each plat, when different fertilizer treatments will be begun.

The Kainaliu plats appear to be very uniform in soil and in tree growth, and the preliminary period used in the experiment at Kealakekua is being dispensed with at Kainaliu. Four different fertilizer treatments are being used: Nitrogen alone, nitrogen and potash, nitrogen and phosphorus, and complete fertilizer. The four treatments, together with a check, are replicated five times (25 plats in all). Growth notes are being taken and plat yields of coffee cherries recorded. Ditches have been dug between the plats to prevent border trees from using fertilizer from adjoining plats. This ditch was considered to be more desirable than the usual check row, because of the small size of the field available and the greater variability resulting from increasing the distance between plats.

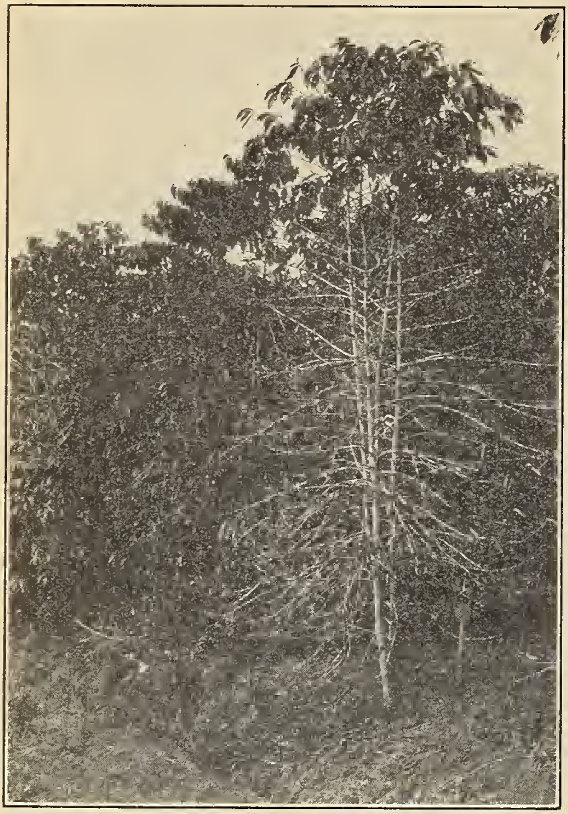

FIGURE 6.—Difference in growth cycles of coffee trees is an important cause of variation in yields from fertilized plats in Kona. The middle and lower sections of the tree in the foreground are bare of fruiting laterals, because of overbearing and the dry weather that prevailed during the year. This tree will yield very little during the coming year, whereas the trees in the background will make a good yield. The following year these conditions may be reversed

GRASSES

MINERAL COMPOSITION

Work was begun in determining the mineral composition of the pasture grasses in the more important ranching areas on Hawaii. Experimental plats were eslished on the Parker ranch at four places, viz, Kamuela, Waiki, Keamoku, and Puukapu Tract No. 2; on the Von Holt ranch in Kohala, the Hind ranch in Puuwaawaa, the Greenwell ranch in Kealakekua, the Kapapala ranch at Kapapala and at Ohaikea, and the Shipman ranch at the Volcano and in Waipahoehoe. Each experiment occupies a tract 30 feet by 20 feet. Half of each tract receives fertilizer applications at the rate of 1,000 pounds of limestone, 300 pounds of superphosphate, and 100 pounds of potassium sulphate per acre. A wire cage, or quadrat, 6 feet wide by 9 feet long by 3 feet high (fig. 7) is placed so that half of it rests on the fertilized strip and the other half on the unfertilized strip. The purpose of the fertilized and unfertilized strips outside the quadrat is to make possible the determination of differences in palatability and changes in grass population under actual grazing conditions. The area in the quadrat is to be cut at intervals of two months throughout the year. Fertilized and unfertilized samples from each strip will be sent to the central station in Honolulu for determination of their nutritive constituents and for analyses for calcium and phosphorus. The grass in each quadrat has been restricted as much as possible to one species or to similar different species. The nongrass growth will be separated from the grass samples before the analyses are made. An annual botanical count will be made of the principal grass species found in the fertilized and unfertilized strips to learn what changes in grass population the fertilizer causes.

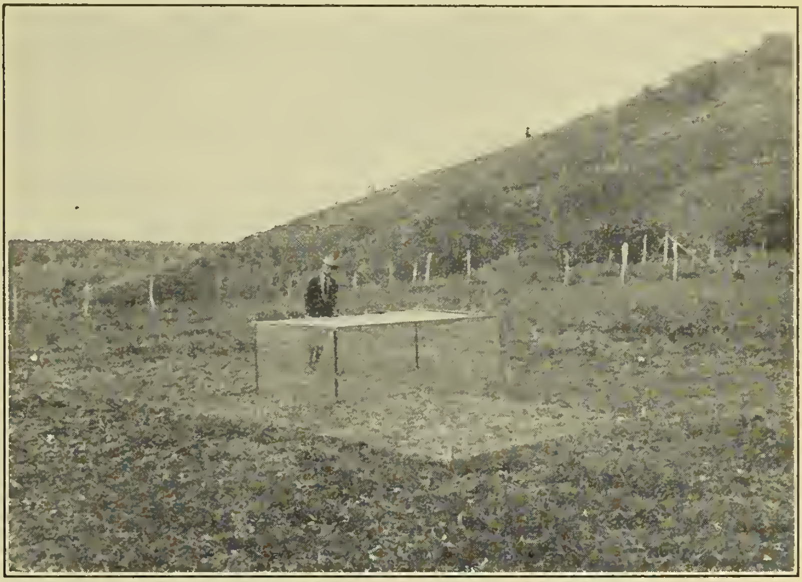

FIGURE 7.—Quadrat method of studying the mineral composition of grasses. The strip on the lower side has been fertilized, whereas that on the mountain side serves as a check. The wire cage (quadrat) is placed so that half of it rests on the fertilized strip and the other half on the unfertilized strip. Samples of grass for analysis are cut from each half at bimonthly intervals

PRINCIPAL SPECIES IN HAWAII

Sixty-five different kinds of grasses, legumes, and herbaceous plants were collected from the cattle ranges on Hawaii. Each was photographed to show how it grew under field conditions. Eighty samples of grasses were analyzed for determination of their chief organic and mineral constituents. The chemical division, working in cooperation with the local agricultural extension division, recorded the opinions of various ranchers regarding each grass.

STARCHES

Previous investigations showed that the cations present in a starch bear an important relation to its properties. Analyses were made of the total potassium, sodium, calcium, magnesium, and phosphorus in a series of 45 starches, including commercial samples of potato, edible-canna, corn, wheat, and cassava starch. Work was begun to learn whether the cations differ in their degree of replaceability. Viscosity and swelling power of the starches are also being determined.

MISCELLANEOUS ANALYSES

Numerous samples of brackish irrigation water and of garden soil were analyzed in connection with the local gardening industry. Nutritive and mineral analyses of 10 of the more commonly used oriental foods were made. The refractometer method of determining the oil content of avocados was studied as a means of aiding the local avocado industry. This method permits the determining of the oil content in about 30 minutes. Several local varieties of avocados, picked at different stages of ripeness, were analyzed.

REPORT ON SPECIAL AVOCADO CHEMICAL INVESTIGATIONS

By Leonora N. Bilger, W. Y. Young, and Ruth C. Robbins

In addition to the experimental work done, an historical review was prepared dealing with problems of avocado preservation, bitter substances of plant origin, and the nature of tannins and their detection in the fruit, and a bibliography of the literature concerning the avocado was compiled.

ISOLATING THE BITTER PRINCIPLE

The experimental work resulted in the isolation, study of properties, and determination of the chemical composition, molecular weight, and formula of avocado tannin. The procedure in the isolation of the tannin was as follows: About 1,600 grams of fresh seeds were sliced into boiling 95 per cent alcohol, removed after being allowed to boil for a few minutes, dried, and ground fine enough to pass through a 20-mesh sieve. The pulverized material was extracted with 50 per cent alcohol until the solvent became clear. The 95 per cent alcohol used for sterilizing the material was diluted and further used for completing the extraction. The alcohol solution was strained through cheesecloth, filtered again, and extracted in a separatory funnel with a 50:50 alcohol and ethyl acetate mixture that had been saturated with salt. The alcohol-ethyl acetate extract was then evaporated to dryness in vacuo, and the residue was treated with water and filtered. The clear filtrate was saturated with salt and extracted with pure ethyl acetate. The extract was again reduced to dryness under low pressure, dissolved in 20 cubic centimeters of distilled water, extracted several times with pure ether to remove fats and other impurities, and finally extracted with ethyl acetate. Salt was added to saturate the water layer. The ethyl acetate-salt treatment was repeated twice, and the aqueous solution was finally extracted with pure ethyl acetate.

Ethyl acetate of the greatest purity was used for the extraction. In view of the fact that the tannin is comparatively more soluble in water than in the acetate, the extraction was repeated fifteen times, 10 to 15 cubic centimeters of solvent being used each time.

The aqueous layer gradually became lighter in color and was roughly tested from time to time to determine the amount of dissolved tannin it contained. The extraction was continued until only a negligible amount of tannin was indicated with ferric chloride.

The final ethyl acetate extract was evaporated in a vacuum distillation apparatus to about 20 cubic centimeters. Evaporation to dryness was completed in a vacuum desiccator after the concentrated extract was transferred to a suitable crystallizing dish. The evaporation was hastened by warming the dish to about 60° C. before placing it in the desiccator. Toward the end of the evaporation, the vacuum was carefully regulated so as to prevent too rapid boiling and foaming of the sirupy residue.

To remove the last traces of ethyl acetate, fats, resins, and other impurities of a similar nature, the residue was washed several times with pure anhydrous ether in which the tannin is practically insoluble. After the product was again evaporated to dryness it was transferred to a vacuum desiccator and completely freed from the ether. The pure product weighed 4.36 grams, representing 0.07 per cent of tannin, calculated on the dry basis. The final product was friable and crisp, of a light tan color that darkened on exposure to light and air, completely soluble in water, alcohol, ethyl acetate, and acetone, and insoluble in ether, chloroform, and benzene. The taste was bitter and astringent, and no odor was detected. The absence of glucosides of the ordinary type and of alkaloids was established.

It is well known that the bitter taste is often absent until certain substances present undergo simple changes, such as hydrolysis. The study of the behavior of avocado tannin led to the conclusion that the hydrolysis of tannins causes the bitter taste noted when the avocado is heated under various conditions. Ethylene treatment of the avocado was begun with a view to removing the tannins, the methods developed by Harvey (*5*) being used for the purpose.

STEROL CONTENT AND VITAMIN VALUE OF AVOCADO OIL

The customary methods of oil extraction when applied to the avocado gave low yields, due apparently to the tight cell structure of the fruit. These methods included (1) mechanical pressing, (2) trying out the oil at about 75° C., (3) prolonged boiling with water and collecting the oily layer, (4) extracting with ether in a Soxhlet apparatus, for which purpose fresh material, dried material, rotted material, and rotted and dried material were used, and (5) centrifuging the mashed rotted pulp to throw out the oil. Of these methods, mechanical pressure and ether extraction proved to be the most satisfactory. The pressure method, however, resulted in a low yield and required subsequent purification of the oil. The extraction method gave a fairly good yield, but required too much time and a relatively large amount of ether.

Under the method finally developed the ripe avocados were washed, peeled, and frozen for about 24 hours in an electrical refrigerator at a temperature of −4° C. They were then covered with a thin layer of water and melted on a water bath at a temperature of about 75° C. Alternate freezing and melting were repeated three times. The warm material was placed in 50-cubic centimeter centrifuge tubes and centrifuged for five minutes at the rate of about 1,800 revolutions per minute. As a result the oil and the avocado mass packed at the top of the tubes and the water collected at the bottom. The water was poured off by making a channel between the avocado mass and the side of the tube with a narrow spatula. The tubes and the contents were warmed in a water bath, and centrifuging was repeated for 15 minutes. A clear, yellow oil collected on the top of the solid mass. This oil was removed immediately so as to prevent it from becoming distributed through the solid material. If additional water collected, it was removed and centrifuging was repeated.

From 20 to 30 cubic centimeters of ethyl ether were added to the solid material left in each tube, and the whole was thoroughly mixed and centrifuged for 15 minutes. The ether solution of the oil was transferred to a distillation flask immediately. Treating with ether and centrifuging were repeated on the solid material remaining in the tubes. The new extract of oil was added to the first quantity. The ether was removed by distillation over a water bath. A 10 per cent yield of clear, yellow oil was obtained. The comparatively large yield of oil, its purity and comparative freedom from rancidity, and the simplicity of the procedure offer distinct advantages over the results obtained by the other methods described. It is easily adapted to large-scale extraction. This work is to be continued with a view to establishing the chemical nature of the sterols and their nutritive value. Since certain vitamins are thought to be sterols, it is desired to determine whether avocado sterols are vitamins or have vitamin value. Study will be made by animal experimentation.

The avocado oil obtained by the method above described was used to isolate the sterol. Fifty grams of oil were placed in a 1-liter flat-bottomed flask connected with a reflux condenser and with a round-bottomed 700-cubic centimeter flask containing 400 cubic centimeters of aldehyde-free 95 per cent alcohol. This alcohol was prepared by distillation with *p*-phenylenediamine hydrochloride and tested for aldehydes by reduction of silver nitrate. The two flasks were placed on a water bath, and the alcohol was distilled through the warm oil, being refluxed and collected in a layer on top of the oil. This alcohol layer was replaced in the round-bottomed flask and the alcohol distilled through the oil again, leaving about 100 cubic centimeters of alcohol to contain the sterol dissolved out of the oil by the first extraction. This process was repeated three times, by which time most of the sterol content of the oil had been transferred to the alcohol solution. The alcohol solution was then evaporated to 250 cubic centimeters, and 20 cubic centimeters of 1-to-1 potassium hydroxide were added to the hot alcohol when the mixture was boiled for 10 minutes. This was then added to 500 cubic centimeters of warm ether in a large separatory funnel and thoroughly mixed, care being taken not to permit the formation of an emulsion.

Three hundred cubic centimeters of water were then added, and the alcohol-soap-water layer was drawn off. The ether was washed with water until free from soap. The ether solution of the sterol was evaporated to 25 cubic centimeters, placed in a 50-cubic centimeter beaker, and evaporated to dryness on a water bath. A yellow residue resulted. Five cubic centimeters of acetic anhydride were added, and the mixture was heated to boiling for a few minutes over a free flame. The mixture was cooled, and 35 cubic centimeters of 60 per cent alcohol by volume were added. A white precipitate which resulted was filtered off and washed with 60 per cent alcohol. The precipitate was dissolved in a stream of hot 80 per cent alcohol by volume, collected in a small flask, and placed in the ice chest at 12° C. The sterol crystallized out in small white crystals. These were recrystallized from hot absolute alcohol and allowed to evaporate in a small weighing bottle. The weight of the product was obtained after being allowed to dry for one hour at 100° C. This material was used to determine the melting point.

REPORT OF THE HORTICULTURAL DIVISION

By W. T. Pope

PROPAGATION OF TROPICAL FRUITS AND NUTS

Throughout the Hawaiian Islands there are large numbers of species and varieties of tropical and subtropical fruit plants of considerable economic value. Many of them are grown to a small extent, and the best methods of their propagation and culture are not well understood. The horticultural division devoted part of its time to an investigation of the possibilities of these plants and to the development of suitable methods of propagating them. Similar studies were made of certain economic plants that are new to the Hawaiian Islands.

The numerous plants propagated during the year included the litchi (*Litchi chinensis*), mabolo (*Diospyros discolor*), Ceylon olive (*Elaeocarpus serratus*), Australian rednut (*Hicksbeachia pinnatifolia*), cashew nut (*Anacardium occidentale*), mamey sapote or sapodilla (*Achras zapote*), egg fruit (*Lucuma obovata*), water apple (*Eugenia aquea*, a station hybrid), coffee (*Coffea arabica* and *C. robusta*), tung-oil tree (*Aleurites fordii*), cacao (*Theobroma cacao*), horseradish-tree (*Moringa oleifera*), sapucaia nut (*Lecythis zabucajo*), cohune nut (*Attalea cohune*), and the pili nut (*Canarium ovatum*).

MAMEY APPLE

Seed-germination experiments were in progress with the mamey apple (*Mammea americana*). The seeds were sown in clean coral-sand mediums and in a light humus soil. The best results were obtained from the use of the coral sand. The medium, however, was found to be less important than the removal of the seed coat immediately before the seed is planted. Seeds so treated germinated in a few days, whereas those not having their tough, thick seed coats removed required from five weeks to several months in which to germinate. This tropical American fruit has been only sparingly grown in Hawaii for many years. Recently, however, trees producing unusually good fruit have attracted attention. Good varieties are reported to have been established in the West Indies through vegetative propagation by inarching. It has also been observed that neither the tree nor the fruit is attacked by such insects as are commonly destructive to many fruits in Hawaii.

BREADFRUIT

Propagating material, consisting of cuttings taken from the surface roots, of Samoan seedless breadfruit trees were received for trial in December, 1930. This material made over two hundred 5-inch root cuttings ranging from 1 inch to 1¾ inches in diameter. The cuttings were sprouted in the propagating house in a bench about 10 inches deep. A 2-inch layer of rich garden soil was spread in the bottom of the bench and overlaid with an 8-inch layer of coral sand. The cuttings were placed horizontally 2 to 3 inches apart about 2 inches below the surface of the sand, which was then slightly firmed and watered daily. After six months this method of propagation has given a fair percentage of plants of suitable size for potting in gallon containers. After making further growth the plants will be transplanted to permanent place in the ground. (Figs. 8 and 9.) Seedless breadfruit has been propagated by this method at the station for several years in cooperation with G. P. Wilder. Mr. Wilder has introduced breadfruit varieties from other tropical Pacific islands for trial in Hawaii.

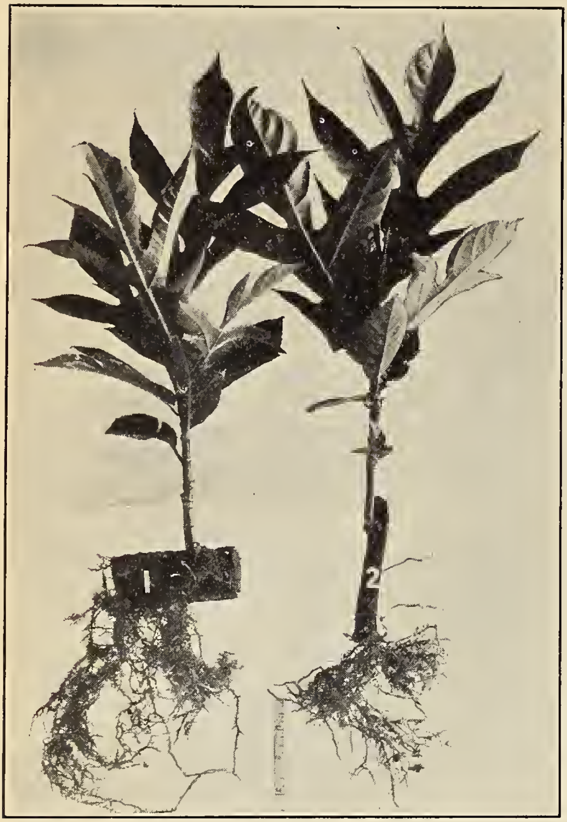

FIGURE 8.—Plants of the seedless breadfruit tree propagated from piece-root cuttings. No. 1 is from a cutting that was buried horizontally in coral sand, and No. 2 is from a cutting that was rooted in upright position with the top exposed above the sand

PANAMA BERRY TREE

The Panama berry tree (*Muntingia calabura*) (No. 4768) [2] is a native of tropical America and may be of value in Hawaii. (Fig. 10.) Some half a dozen of the trees were introduced at the station for the first time on July 26, 1922. They did not attract attention, however, until they began to bear fruit during the last two or three years. The tree is remarkable for the abundance of very small seeds in the pulp of the edible fruit. Germination is effected (1) by drying the fruit, cutting it into very small pieces containing the seeds, and planting them in fine, sifted soil; and (2) by squeezing the seed-laden juice on to a firmed surface of sifted soil that is topped with a light, thin covering of pith of the coconut finely grated. Optimum moisture conditions are maintained by allowing water to soak into the ground from below or from one side of the plantings.

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[2] Number under which plants were received at the station.

CERIMAN

The ceriman (*Monstera deliciosa*) is a tropical American climber of early introduction into Hawaii. It is grown to some extent on rock-work and on tree trunks as an ornamental. When grown in the open it is spreading in form and increases in prolificacy. The edible fruit has a pleasing flavor which is somewhat like that of the pineapple. The ceriman is easily propagated from cuttings of the mature stems. Each cutting should contain several nodes and the cuttings root best when half buried horizontally in rich sandy loam. The ripe fruit occasionally contains a few seeds near the base. These germinate easily in sand or in light soil. (Fig. 11.)

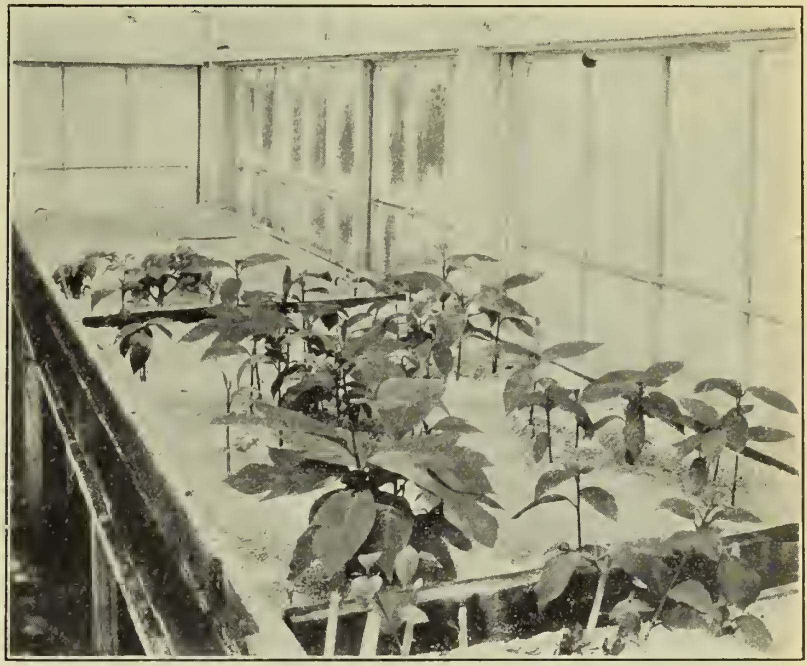

FIGURE 9.—Propagating bed of seedless breadfruit plants developed from root cuttings

MACADAMIA NUT

Macadamia-nut investigations have been in progress at the station for several years. The unusual interest taken in growing this tree commercially indicates the importance of giving further study to its habits of variation, vegetative methods of propagation, and general cultural requirements. The investigations have been made at the station and in the orchards of private growers. The tree exhibits many variations both in time of blooming and in nature of blossoms. It blooms mainly in April but may bloom a few weeks earlier or later. The time of blooming is possibly influenced by immediate local climatic and soil conditions. Trees are commonly found which bloom continuously and mature nuts during the greater part of the year, but they produce no large crops in any one period.

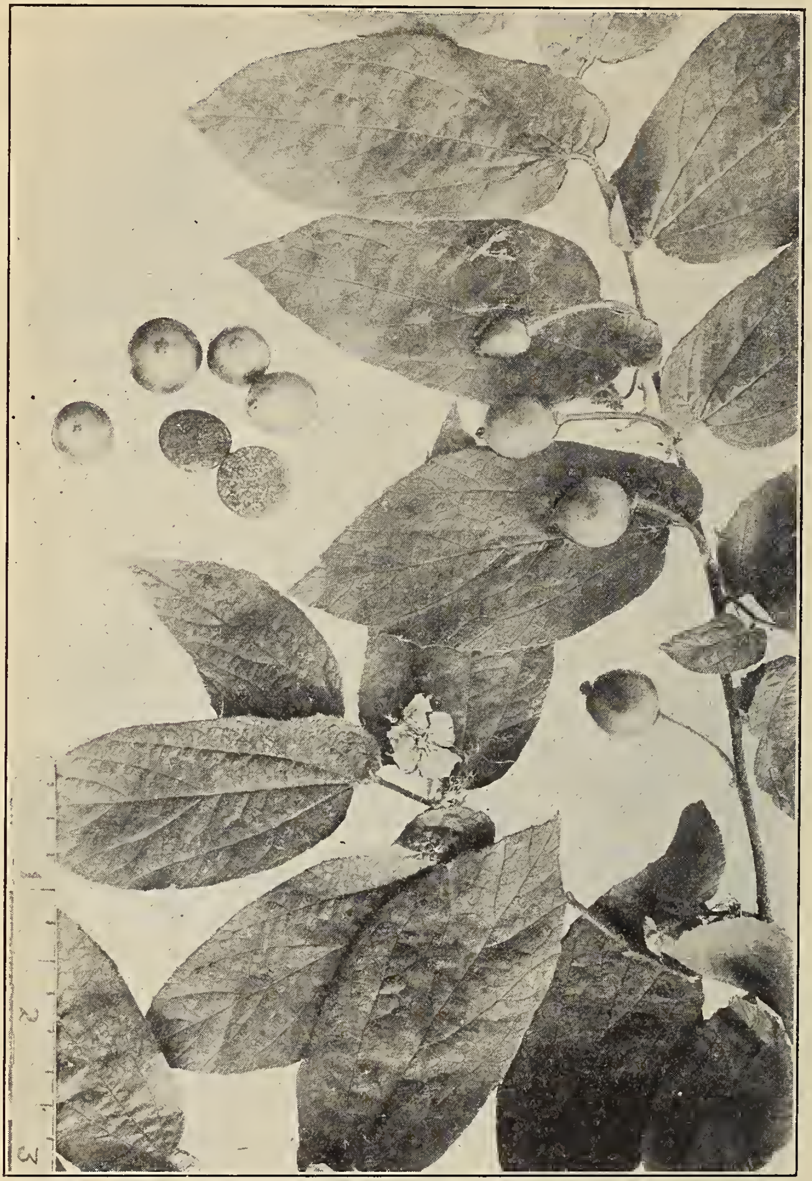

FIGURE 10.—Panama berry (*Muntingia calabura*). The fruit of this tropical American tree is of pleasing flavor

Some Macadamia trees have two blossoming periods and two crop-maturing periods. These are in the spring and in the fall. Nuts resulting from the spring blossoms mature about the time the fall blossoms are due, or just before. Most Macadamia trees, however, bloom heavily in the spring and mature their crop in the fall. This condition is the one preferred by most commercial growers. It is believed that a regular season of bearing can be controlled by use of vegetative propagation and cultural methods.

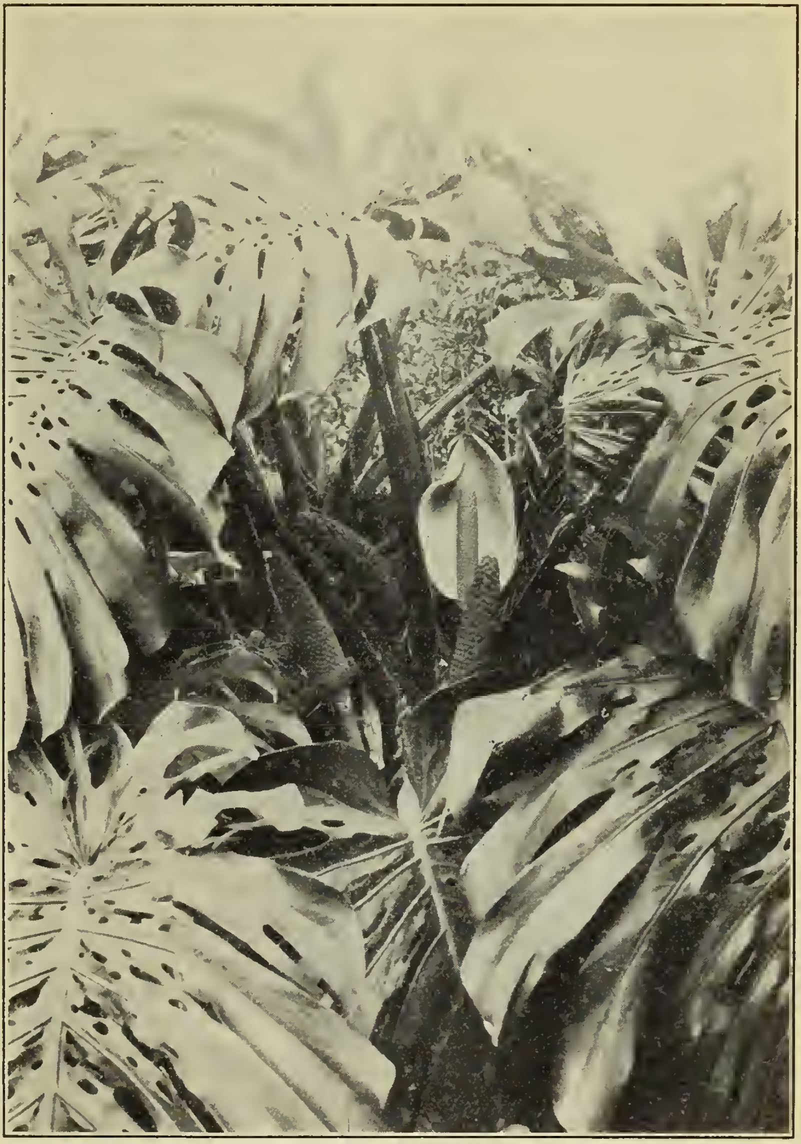

FIGURE 11.—Ceriman (*Monstera deliciosa*) grown from a cutting. It is about 7 years old and has been fruiting freely for several years

In observations on variation in inflorescence of different seedling trees it was found that in an orchard of 60 seedlings about half the trees bore white or cream-colored flowers, whereas the rest were of pinkish and reddish shades. Color of flower does not appear to be correlated with quality of nut. Individual catkins vary in length and in number of flowerets. Catkins average about 12 inches in length, although a number of them were found during the year to measure from 18 to 22 inches. The flowerets often number several hundred per catkin. Most of them are shed naturally during the latter part of the blooming period. Many that do set are shed as small nuts during their early growth. The trees naturally retain as many as they are able to bear to maturity. The number of nuts matured to a catkin ranges ordinarily from 1 to 12. Some catkins were found with 20 or more to the cluster, and several had more than 100 nuts to a cluster.

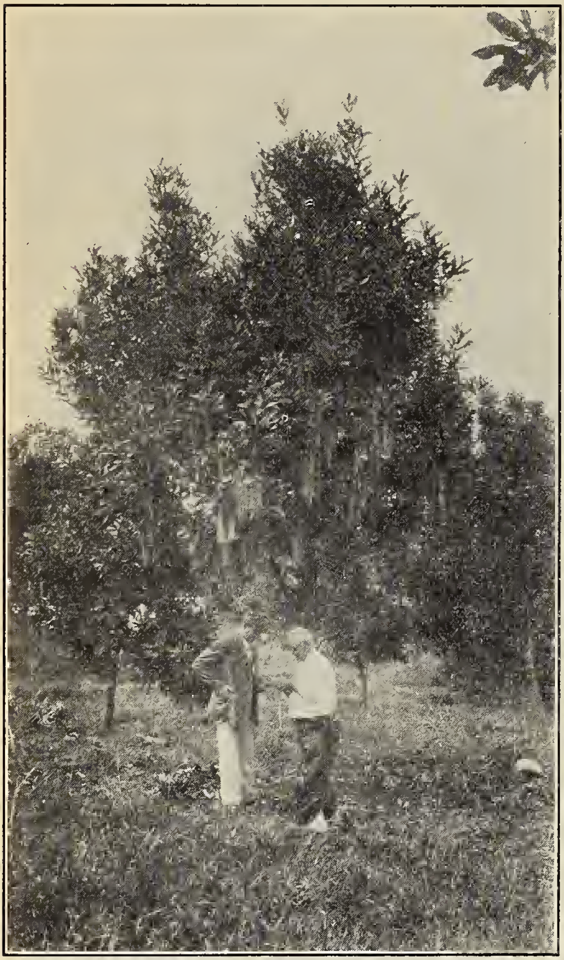

FIGURE 12.—Macadamia-nut tree in bloom. The flowers are borne on long catkins which give the tree a beautiful appearance

Large numbers of seedling trees bear heavily at the proper age, which is about 12 years. These habits of bearing may be perpetuated by using vegetative methods of propagation for the establishment of trees on a commercial basis. (Fig. 12.) During the fall of 1930 a study was made of the variation of nuts of different seedling trees. More than 50 per cent of the trees examined produced nuts undesirable for commercial use, being too small, thick-shelled, rough-surfaced, irregular in shape, or of poor flavor. Rooting the cuttings has not been satisfactorily practiced as a method of propagation. Topgrafting 1-year-old or 2-year-old seedlings in permanent place has been a success under some unusually moist conditions.

New seed was obtained from several sources. Some large spherical nuts were obtained from Australia through cooperative exchange. These were germinated and the resulting seedlings planted in the experimental plat at the Kona substation. Medium-sized, thin-shelled nuts were also obtained and are being propagated.

AKALA OR NATIVE RASPBERRY AND OTHER SPECIES OF RUBUS

During the first week in April, 1931, the horticulturist made a trip to Mount Hualalai, island of Hawaii, for the purpose of studying the akala plants growing there. One species of akala (*Rubus hawaiiensis*) forms the greater part of the undergrowth in what is considered to be the timber-line region, where the elevation is about 6,000 feet. In many places the plants were in fruit. (Fig. 13.)

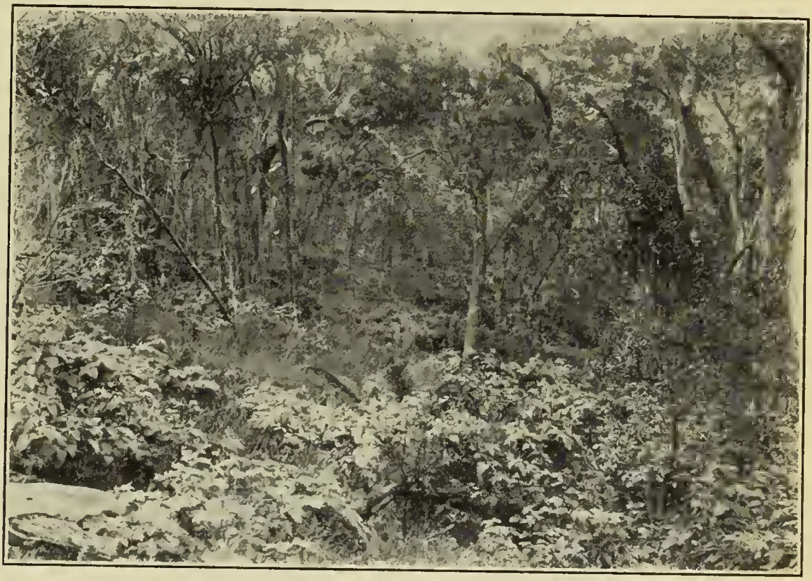

FIGURE 13.—Akala plants spreading in the open woods of the forest reserve, Hualalai. After cattle were shut out for 2½ years the akala plants began to form a large portion of the necessary undergrowth for the natural forest. Elevation of this part of the forest reserve is about 6,000 feet. (Photographed April 11, 1931)

Ripe fruit has been collected by the forest ranger as early as April 1. In some places another species (*R. macraei*) was found growing among these upright plants. The plants are prostrate and roving in habit and do not blossom until late in the summer in this part of Hawaii, and the fruits, which are rather large, ripen during late August and early September. Sprouting root clumps were dug up with the rich soil adhering to the roots and packed in paper and burlap for shipment to the central station in Honolulu. Eighteen clumps, nine plants of each of the two species, were brought down the mountain by pack mule 9 miles to Holualoa, whence they were transported by automobile to the Kona substation and thence shipped to Honolulu. During the following week they were set out on the mountains of Oahu, where the elevation ranges from 2,200 feet to 3,700 feet. It is hoped that these two species will become established and widely spread from seeds dropped by birds, as was the case on the island of Hawaii. It is believed that their success on Oahu will aid in the work of adapting them to the lower elevations.

The propagation of Rubus species, particularly the raspberry, is difficult. None of the species thrives at the lower elevations in these islands. Seed of most of the species tried has failed to germinate. With possibly one exception this was found to be true of the wild native raspberry, or akala, that grows on the upper forest reserves. Seeds of *Rubus hawaiiensis* were obtained from different localities in July, 1930, and again in April, 1931. Some of these seeds were brought to the central station in the fruit, others had been removed from the fruit and after being allowed to dry for a few days were planted, and a third lot was mixed with a quantity of humus from the forest in which the plants grew. The first two lots were divided into two groups each and placed for germination in coral sand and in light soil mediums. The humus containing the seeds of the third lot was used as a surface layer on one portion of sand and on soil prepared in the germinating flats. Although the seeds had been planted two months before, they had not germinated June 30, 1931. Plants of both *R. hawaiiensis* and *R. macraei* were removed with the soil adhering to the roots, from their natural habitat on Hawaii, where the elevation is 6,000 feet, and transplanted on Oahu, where the elevations range from 2,200 to 3,700 feet. Opportunity for experimental work with them is better on Oahu than on Hawaii. Both species have some very promising characters. Seeds of a wild species of Rubus with edible fruit were recently introduced into Hawaii from Java by the station. The dried seeds were soaked in water for several hours before they were planted and gave a high percentage of germination a few days later.

Most of the varieties introduced from the mainland of the United States failed to grow well in any of the trials made at the different elevations. More than half of the introduced 19 varieties died. The varieties making the best growth included dewberries, blackberries, and a Philippine species of raspberry. In December, 1930, two plants each of six varieties were set out in a cooperative experiment at the Kilauea Volcano House garden, where the elevation is 4,000 feet, and two plants each of four varieties were set out in a private garden near Glenwood, island of Hawaii, where the elevation is about 3,200 feet. These locations have a cool, even temperature with a normal annual rainfall of about 100 inches at the Kilauea Volcano House and 189 inches at Glenwood. The plants showed little growth four months after they were set. The horticulturist observed, when on a visit to a private garden on West Maui, where the elevation is 2,300 feet, that both dewberries and blackberries were doing well, and that the former were rather prolific. The blackberry plant fruits well in the vicinity of Kilauea Volcano House on Hawaii and in Makua Valley on Oahu. Introduced raspberry and blackberry plants are reported as growing successfully in the Hamakua district, Hawaii.

KONA SUBSTATION EXPERIMENTS

The station enlarged several of its horticultural projects considerably by making permanent plantings at the Kona substation near Kealakekua, Hawaii, which was recently acquired for experimental purposes. Approximately 2 acres of land there are now devoted to horticultural plantings. For several years this land had been overgrown with wild grasses and utilized for pasturage. In October and again in November, 1930, the land was deeply plowed and cleared of roots and stones. Planting was begun on December 5, following the early rains. Investigations are concerned principally with the Macadamia-nut tree, coffee, and miscellaneous fruits.

FRUIT AND NUT PLANTS UNDER OBSERVATION

An annotated list of the plants under observation is given herewith:

Macadamia-nut tree (*Macadamia ternifolia*): 10 trees (No. 5589)[3], 19 trees (No. 5588), 1 tree (No. 5481) producing large nuts, and 2 trees (No. 5482) producing thin-shelled nuts.

Pili nut (*Canarium ovatum*): 1 tree (No. 5601).

Citrus: Pomelo or grapefruit (*Citrus grandis*)—Royal variety, 1 tree (No. 1685), Whitney Imperial variety, 1 tree (No. 2704), and Marsh variety, 1 tree (No. 1585), Victoria variety, 2 trees (Nos. 4835.1 and 4835.2), and a Siamese variety, 1 tree (No. 5501); lemon (*C. limonia*)—rough variety, 1 tree (No. 1596), Ponderosa variety, 1 tree (No. 2938), Eureka variety, 1 tree (No. 1653.1); lime (*C. aurantifolia*)—Kusaie variety, 1 tree (No. 5592), a Tahitian hybrid, 2 trees (Nos. 4650.1 and 4650.2), Rangpur variety, 1 tree (No. 5577); orange (*C. sinensis*)—a Hawaiian variety, 6 trees (Nos. 5570.1, 5570.2, 5570.3, 5570.4, 5570.5, and 5570.6), Ruby variety, 1 tree (No. 1561.1), Thomson, 2 trees (Nos. 1609.1 and 1609.2), and Valencia variety, 1 tree (No. 1590.1).

Coffee: a Hawaiian variety (*Coffea arabica*), 15 plants (No. 5497); Robusta variety (*C. robusta*), 18 plants (No. 5575); and 9 trees of unknown varieties.

Papaya (*Carica papaya*): Solo variety, 200 plants (No. 5595).

Mulberry (*Morus nigra*): 4 plants (No. 5593).

Avocado (*Persea americana*): 1 tree each of the varieties Nabal (No. 4467.1), Rey (No. 5532.2), Panchoy (No. 4253), Beardslee (No. 4075.2), Ilialu (No. 4696), Haley (No. 4821.2), Ishim (No. 4261), Kaguah (No. 4433), Linda (No. 5547), Sexton (No. 3841), Dry (No. 5514), and Lewis (No. 4848), and two trees of the variety Fuerte (Nos. 4559.1 and 4559.2).

Sapucaia nut (*Lecythis zabucajo*): 2 trees (No. 5484).

Cashew nut (*Anacardium occidentale*): 2 trees (No. 5522).

Egg fruit (*Lucuma nervosa*): 1 tree (No. 5535).

Sugar-apple (*Annona squamosa*): 1 tree (No. 5490).

Kawa (*Nephelium pinnatum*): 1 tree (No. 5400).

Surinam cherry (*Eugenia uniflora*): 1 tree (No. 5563).

Star-apple (*Chrysophyllum cainito*): 1 tree (No. 5594).

Passiflora spp.: 6 trees (*P. alata*) (No. 5513); Lilikoi variety (*P. edulis*), 4 trees (No. 5510); 1 hybrid tree (No. 5511); and a Fiji variety, 1 tree (No. 5478).

Litchi (*Litchi chinensis*): San Hing variety, 1 tree (No. 3890); and Hak-Ip variety, 1 tree (No. 3878).

Mabolo (*Diospyros discolor*): 2 trees (No. 5569).

Fig (*Ficus carica*): Kadota variety, 1 tree (No. 5567); and Mission variety, 1 tree (No. 5566).

Lanzon (*Lansium domesticum*): 2 trees (No. 5390).

Garcinia (*Garcinia binucao*): 1 tree (No. 5498).

Mamey apple (*Mammea americana*): 2 trees (No. 5568).

Cacao (*Theobroma cacao*): 2 trees (No. 5565).

Ceriman (*Monstera deliciosa*): 1 tree (No. 5564).

Bulso (*Gnetum indicum*): 1 tree (No. 5448).

Vangueria edulis: 1 tree (No. 5397).

Tung-oil tree (*Aleurites fordii*): 1 tree (No. 5560).

Brazil cherry (*Eugenia dombryi*): 2 trees (No. 5561).

Breadfruit (*Artocarpus incisa*): unknown variety, 1 tree (No. 5474); and 1 tree from Tahiti each of the varieties Kuahe (No. 5473), Hamoa (No. 5406), Puera (No. 5424), and Ula Maopo (No. 5491), Morave (No. 5401) from Rarotonga, and a seedy kind (No. 5391) from the Philippines.

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[3] Number under which the plants were received at the station.

Tomato (*Lycopersicon esculentum*): 50 plants each of the varieties Landreth (No. 5553) and Globe (No. 5549); 40 plants each of the varieties Earliana (No. 5555), Great Baltimore (No. 5550), Break O'Day (No. 5554), Norton (No. 5552), Marglobe (No. 5551), Walter Richard (No. 5548), Bonny Best (No. 5557), and Bloomsdale (No. 5556); and 35 plants of a hybrid (No. 5590).

INTRODUCTIONS

About 70 kinds of fruit plants were introduced at Kona during the year and included the following:

Cashew nut (*Anacardium occidentale*) (Nos. 5519, 5522, and 5562)[4]; attalea palm (*Attalea gomphococca*) (No. 5520); papaya (*Carica papaya*) (Nos. 5521, 5545, 5595, and 5597); white sapote (*Casimiroa edulis*) (No. 5523); sapote (*Calocarpum mammosum*) (No. 5546); palm (*Guilielma utilis*); poha (*Physalis peruviana*), Cape Gooseberry variety (Nos. 5525 and 5526); Jambolan plum (*Syzygium cumini*) (No. 5527); avocado (*Persea americana*), Bicknell variety (No. 5528), Makai variety (No. 5531), Rey variety (No. 5532), Mauka variety (No. 5533); Linda variety (No. 5547), and Mexican variety (No. 5599); *Saraca indica* (No. 5529); jackfruit (*Artocarpus integra*) (Nos. 5530 and 5603); magnolia (*Magnolia grandiflora*) (No. 5534); egg fruit (*Lucuma obovata*) (No. 5535); breadfruit (*Artocarpus incisa*), Aveloloa variety (No. 5536), Ulumanua variety (No. 5537), Puou variety (No. 5538), Maopo variety (No. 5539), miscellaneous kinds (No. 5540), Ulumasee variety (No. 5541), and Ulu-Puou variety (No. 5542); carob tree (*Ceratonia siliqua*) (No. 5543); red castor bean (*Ricinus* sp.) (No. 5544), tomato (*Lycopersicon esculentum*), Walter Richard variety (No. 5548), Globe variety (No. 5549), Great Baltimore (No. 5550), Marglobe variety (No. 5551), Norton variety (No. 5552), Landreth variety (No. 5553), Break O'Day (No. 5554), Earliana variety (No. 5555), Bloomsdale variety (No. 5556), Bonny Best variety (No. 5557), and a hybrid (No. 5590); Ceylon olive (*Elaeocarpus serratus*) (No. 5558); *Inga edulis* (No. 5559); tung-oil tree (*Aleurites fordii*) (No. 5560); Brazil cherry (*Eugenia dombeyi*) (No. 5561); Surinam cherry (*E. uniflora*) (No. 5563); ceriman (*Monstera deliciosa*) (No. 5564); cacao tree (*Theobroma cacao*) (No. 5565); fig (*Ficus carica*), varieties Mission (No. 5566) and Kadota (No. 5567); mamey apple (*Mammea americana*) (No. 5568); mabolo (*Diospyros discolor*) (No. 5569); Hawaiian variety of orange (*Citrus sinensis*) (No. 5570); horseradish-tree (*Moringa oleifera*) (No. 5571); yellow strawberry guava (*Psidium lucidum*) (No. 5573); wild Javan raspberry (*Rubus* sp.) (No. 5574); coffee (*Coffea arabica*) (No. 5575); amaryllis (*Amaryllis* sp.) (No. 5577); *Parkia speciosa* (No. 5578); sapucaia nut (*Lecythis zabucajo*) (No. 5579); Macadamia-nut tree (*Macadamia ternifolia*) (Nos. 5588 and 5589); sugar-apple (*Annona squamosa*) (No. 5591); Kusaie lime (*Citrus limonia*) (No. 5592); black mulberry (*Morus nigra*) (No. 5593); star-apple (*Chrysophyllum cainito*) (No. 5594); *Passiflora fruticosa* (No. 5596); *Attalea cohune* (No. 5598); mahogany (*Swietenia mahagoni*) (No. 5600); pili nut tree (*Canarium ovatum*) (No. 5601); and allspice (*Pimenta officinalis*) (No. 5602).

ARBORETUM

Since the organization of the station in 1901 the horticultural division has developed several small experimental orchards of such leading fruits as the avocado, citrus, mango, banana, litchi, papaya, and fig, and also a group of miscellaneous fruit trees. All have been found to be of value for investigational purposes and as a source of propagating material for distribution to cooperative and private growers both in the Territory of Hawaii and in other tropical and subtropical parts of the world. These orchards are also of great assistance to entomologists of the United States Department of Agriculture who are now in Hawaii studying the Mediterranean fruit fly (*Ceratitis capitata*) and possibly such other undesirable insects as the Japanese beetle (*Adoretus sinicus*) and the mango weevil (*Cryptorhynchus mangiferae*).

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[4] Number under which the plants were received at the station.

The station is suitably located for a great many of the species of crop plants tried. In soil and climatic conditions it is typical of the greater portion of the agricultural land both in the Territory and in other tropical and subtropical countries. These facts were appreciated by the Hawaiian Government (*7 p. 95*) as early as the year 1893, when the station land was set apart for use as a botanical garden or arboretum, and block plantings were begun in acre plats and half-acre plats. These areas now form a forest of silver wattle and black wattle (forms of *Acacia decurrens*), silk-oak (*Grevillea robusta*), *Eucalyptus robusta*, ironwood or beefwood (*Casuarina quadrivalvis*), and camphor (*Camphora officinalis*), and there are a few smaller areas of miscellaneous species, such as the Ceara rubber (*Manihot glaziovii*), Macadamia-nut tree (*Macadamia ternifolia*), Hevea rubber (*Hevea braziliensis*), banana (*Musa* spp.), allspice (*Pimenta vulgaris*), tung-oil nut tree (*Aleurites fordii*), mountain apple (*Eugenia malaccensis*), and sisal (*Agave sisalana*). These plantings have clearly demonstrated the wisdom of the original plan.

The present plan to put out block or large-plat plantings of economically promising tropical fruit and nut trees is a logical development of the work begun here over 30 years ago. This economic tropical arboretum, located just within the Torrid Zone in very healthful surroundings, is in touch with a number of scientific laboratories, libraries, and scientific workers, and presents great advantages for agricultural research. It has been so recognized by a number of branches of the United States Department of Agriculture. The recently approved increased development of the arboretum has started what is hoped will eventually become an extensive area devoted to many species of crop plants for thorough scientific study. Experimental station lands heretofore not fully utilized for crop experiments are being cleared, deeply plowed, and divided into block areas varying from ¼-acre to ½-acre plats of such plants as annonas (*Annona* spp.), breadfruit (*Artocarpus incisa*), pili or canary nut (*Canarium ovatum*), carob (*Ceratonia siliqua*), coffee, cork oak (*Quercus suber*), durian (*Durio zebethinus*), *Eugenia* spp., guava (*Psidium* spp.), Japanese chestnut (*Castanea crenata*), kou (*Cordia subcordata*), lanzon (*Lansium domesticum*), *Lucuma* spp., longan (*Euphoria longana*), Macadamia nut (*Macadamia ternifolia*), mahogany (*Swietenia mahagoni*), mamey apple (*Mammea americana*), sapote (*Calocarpum mammosum*), mangosteen (*Garcinia mangostana*), mulberry (*Morus* spp.), Panama berry (*Muntingia calabura*), *Passiflora* spp., pejibaye palm (*Guilielma utilis*), persimmon (*Diospyros* spp.), pomegranate (*Punica granatum*), rednut (*Hicksbeachia pinnatifolia*), sapucaia (*Lecythis zabucajo*), sapodilla (*Achras zapote*), Tahitian chestnut (*Inocarpus edulis*), tamarind (*Tamarindus indicus*), teak (*Tectona grandis*), tropical olive (*Elaeocarpus serratus*), wampi (*Clausena wampi*), white-sapote (*Casimiroa edulis*), vi-apple (*Spondias cytherea*), and tung-oil tree (*Aleurites fordii*).

REPORT OF THE NUTRITION LABORATORY OF THE HOME ECONOMICS DIVISION

By Carey D. Miller

VITAMIN CONTENT OF CHINESE CABBAGE

Experiments with white rats showed raw Chinese cabbage (*Brassica chinensis*), like other green vegetables, to be a very good source of vitamin A. When Sherman's standards were used, feeding 0.5 gram of the cabbage once a week, equivalent to a daily (except Sunday) supplement of 0.083 gram, was found to give three times the expected gain of 25 grams of body weight for the eight weeks covered by the test. All the larger amounts yielded much greater gains. Experiments on rats fed bran-salted Chinese cabbage indicated a considerable loss of vitamin A in the cabbage resulting from the salting process.

The rice bran used in salting the cabbage was tested on rats to determine its vitamin B content and was found to have high antineuritic properties. Feeding 0.1 gram daily, except Sunday, gave about 30 grams of gain in body weight in the eight weeks covered by the test. Rats were used to test the vitamin B content of raw and salted Chinese cabbage. About 4.5 grams of the raw cabbage seems to be the unit quantity required to supply vitamin B.

The vitamin G content of the bran was tested on rats and found to be low as compared with the vitamin B content. Thus far 23 rats have been used to determine the vitamin G content of the raw and the salted cabbage. At least 5 grams of the raw cabbage, and probably 10 grams of the salted cabbage, are required daily to effect recovery from symptoms of dermatitis.

Experiments on guinea pigs indicated that 2 to 3 grams of the fresh cabbage should be fed daily to protect the animals from scurvy. The bran-salted and the plain-salted cabbage seem to contain only about one-tenth as much vitamin C as does the fresh cabbage.

VITAMIN CONTENT OF THE HAWAII SHELLFISH OPIHI

In continuation of studies of the foods used by both ancient and modern Hawaiians, experiments were begun on the food value of their favorite shellfish, the opihi (*Helcioniscus exerata; H. argentatus*). No figures were available on the organic nutrients of opihi. Analyses showed opihi to contain 76.45 per cent of water, 17.6 per cent of protein (N × 6.25), 1.72 per cent of fat (ether extract), and 2.79 per cent of ash. The ether extract had an odor distinctly like that of cod-liver oil.

Preliminary experiments with rats showed opihi to be a very good source of vitain A. Feeding 0.5 gram of the fresh opihi daily caused the animals to gain 190 grams in eight weeks. Later experiments showed that rats, when fed 0.1 gram of opihi once a week (equivalent to about 0.016 gram daily, except Sunday), lost in weight and died before the close of the experiment. Rats fed 0.2 gram per week gained 60 to 70 grams in eight weeks, whereas those fed 0.4 to 0.5 gram per week gained about as much as those receiving 0.1 gram of cod-liver oil per week. Considered on a moisture-free basis, and measured by the rat-growth method, opihi is as good a source of vitamin A as is cod-liver oil, because 0.4 gram of the raw fresh opihi is equivalent approximately to 0.095 gram of moisture-free material.

Preliminary experiments with rats showed opihi to be very low in vitamin B content. All rats receiving 1, 2, and 3 grams daily lost weight markedly and most of them died before the close of the experiment. One rat receiving 4 grams of opihi gained 42 grams in weight in eight weeks. A second lot, when fed daily 3.5 or 4 grams of opihi, lost 17 to 29 grams in weight per animal. The control animal in this lot lived longer than usual. A third lot, when fed 4 grams of opihi daily, like the animal in the first lot, gained 23 to 30 grams in weight in eight weeks. Possibly there is a seasonal variation in the vitamin B content of opihi, as is the case with the vitamin A content of oysters in New Zealand, or possibly the rats in the second lot were unusual.

In experiments with rats to determine the vitamin G content of opihi, 2 grams of fresh opihi fed daily (except Sunday) caused an average gain of about 75 grams in body weight in eight weeks, but did not always effect a complete recovery from symptoms of dermatitis. Histological work done by a member of the zoology division of the University of Hawaii indicated that even when a gross examination shows apparent recovery from any symptoms of dermatitis the epithelium may be far from normal.

Experiments with guinea pigs showed opihi to have no antiscorbutic properties, even when 4 grams, the largest quantity the animals could be induced to eat, were fed daily. In fact, after 21 days the animals seemed to be in worse condition than were the usual controls. Histological examination of the incisor teeth of the opihi-fed group, as recommended by Höjer (*6*) and later by Eddy (*3*) showed complete degeneration of the odontoblasts.

The line test was used to determine the vitamin D content of opihi (Stenbock's diet 2965). Feeding 4 or 5 grams of fresh opihi daily for eight days gave as complete protection from rickets as did 1 per cent of cod-liver oil in the diet. Feeding 2 grams of opihi daily was not found to be sufficient for complete protection.

HEMOGLOBIN REGENERATION

Nutritional anemia was produced in albino rats by feeding them special milk from the university farm, which contained no copper. The technic used was essentially that of the Wisconsin investigators. Anemic rats fed 4 grams of fresh calf liver daily showed rapid hemoglobin regeneration. Rats fed opihi showed only slight hemoglobin regeneration or none. It is therefore concluded that opihi has little or no value for hemoglobin regeneration in nutritional anemia of the rat. The spleens were found to be much enlarged in all the anemic animals.

VITAMIN C CONTENT OF HAWAII-GROWN ORANGES

Notwithstanding some difficulty in securing a continuous supply of locally grown oranges over a 4-month period because of an unusual season, guinea pigs were fed 1.5 cubic centimeters of locally produced orange juice daily for a period of 90 days. All the animals made moderate to excellent growth, gaining 110 to 250 grams during the period and showing complete protection from scurvy, when Sherman's method was used. At the end of the 90-day period histological examination of the incisor teeth of the animals showed the juice fed to be 0.7 to 0.5 of the fully protective dose. This finding was to be expected in view of the fact that other investigators have shown that 3 cubic centimeters of orange juice daily are required to protect the teeth.

VITAMIN B CONTENT OF RICE-BRAN BREAD

Since rice bran is generally considered to be a good source of the antineuritic vitamin and was found in experiments by the station to be also an inexpensive source of the vitamin, finding some method of encouraging the use of rice bran in human food was deemed to be worth while. The diet of many children, and of many adults also, in Hawaii is undoubtedly low in this vitamin. The largest baking concern in Honolulu was approached on the subject and willingly offered to bake, for experimental purposes, bread in which 20 per cent of rice bran would be substituted for white flour. The bread was fed to rats. White bread plus rice bran and rice-bran bread and white bread were fed daily in equivalent amounts. The white bread proved to be no better than the basal diet alone. The completed experiments indicated a destruction of about 30 per cent of vitamin B in the rice-bran bread.

BIOLOGICAL VALUE OF THE PROTEIN OF THE PIGEON-PEA SEED

Experiments in which rats were used to determine the biological value of the protein of the seeds of the pigeon pea (*Cajanus indicus*), using the Mitchell paired-feeding method with and without cystine, did not give clear-cut results. Enough pure protein from the seed of the pigeon pea has been prepared for further feeding experiments and for chemical analyses.

REPORT OF THE POULTRY HUSBANDRY DIVISION

By C. M. Bice

SOREHEAD (FOWL POX) CONTROL IN BABY CHICKS

The objects of this experiment are (1) to determine the method of transmission of sorehead (fowl pox), identified as epithelioma contagiosum, to baby chicks; (2) to note the efficiency of a "live virus" vaccine in developing immunity against the disease; and (3) to learn the age at which chicks may be vaccinated successfully. In the report for last year (*2, p. 36*) a method of preventing fowl pox by eliminating the mosquito was described. Nine groups of chicks, 200 to a group, varying in age from 1 day to 16 weeks, are being tested to learn the efficiency of a "live virus" vaccine. One group was vaccinated when 1 day old, and each succeeding group at intervals of two weeks. The "stick" method is being used—the right wing is pierced once in the web portion. The preliminary trial was completed, and a second trial was undertaken. Baby poults were vaccinated against turkey pox. The age for vaccination ranges from 1 day to 2 months.

SEX DETERMINATION IN DAY-OLD PUREBRED CHICKS

In an experiment having for its object the finding of some definite sex-linked character in day-old purebred chicks, voice, length of tail, internal copulatory organs in the vent, and position of chick when held by the nape of the neck or by the feet, were studied. The results were not entirely satisfactory.

BATTERY BROODING METHOD FOR CHICKS

An experiment was begun to compare the relative merits of a fireless battery brooder and an electrically heated battery brooder, and the value of the battery brooder with that of an ordinary canopy-type electric brooder now in use in the poultry division of the station. One test was completed in which 1,000 chicks were grouped as equally as possible in the three types of brooders. Cannibalism was observed in the fireless battery brooder on the nineteenth day of the test, whereas it did not begin in the electrically heated battery brooder until the fifth week. Severe cannibalism took place in both battery brooder groups when the chicks were moved to the colony houses. No cannibalism was observed in the chicks under the electrically heated canopy brooder. Mortality was less than 5 per cent for each group.

PAPAYAS, AVOCADOS, BANANAS, AND SWEETPOTATOES FOR POULTRY

Fattening and laying rations containing varying quantities of fruits and vegetables were fed to poultry to determine the feeding value of the papaya, the avocado, the banana, and the sweetpotato. Twelve lots of 10 birds each were placed on the laying rations beginning October 1, 1930. The information gathered is not complete, and therefore definite conclusions can not be drawn.

RAW CANE SUGAR FOR BABY CHICKS

An experiment was begun to determine the feeding value of raw cane sugar for baby chicks. One group of 90 chicks was fed a ration containing 5 per cent of raw cane sugar; a second group of 90 was fed a ration containing 10 per cent sugar; and a third group of 90 was used as a check, receiving no sugar supplement in their ration. The feeding period lasted 13 weeks. The information gathered on the first trial was not significant for accurate deductions and conclusions.

MISCELLANEOUS NOTES

The most common breeds of poultry in Hawaii are maintained at the university farm for instructional and experimental purposes. The minor experiments under way entirely with Territorial funds include (1) determination of the effect of various incubation temperatures under Hawaii climatic conditions, (2) determination of the value of electric lights as a possible preventive of fall molt in early hatched pullets, (3) determination of the part the sire plays in increasing egg production, and (4) determination of the possibility of rearing turkeys in confinement.

REPORT OF THE SOIL PHYSICS DIVISION

By H. A. Wadsworth

The work of the year was concentrated on two investigations. One of these dealt with factors affecting the rate and height of capillary rise of water through soils. Results indicate that capillary rise through soils, or idealized soils, is a compound process in which at least two distinct types of moisture distribution are involved. In the simplest case the initial phase of such rise is characterized by an exponential form for the rise-time curve. The resulting moisture content is uniform, except for trapped air, and essentially equal to the saturation percentage. The second phase of the rise is marked by the parabolic rise-time curve already noted by other investigators. The moisture content decreases uniformly and continuously from the saturated zone at its lower end to about the field capacity at its upper end.

In the second investigation a preliminary study was made of the correlation of the ratios of the moisture equivalents and wilting coefficients of a selected list of economic soils and the silica sesquioxide ratios of the extracted colloids of the soils.

REPORT OF THE HALEAKALA SUBSTATION

By H. F. Willey

GENERAL STATEMENT

At the Haleakala substation selective-breeding work with the pigeon pea was continued; green-manuring cultural tests on pineapples, with and without fertilizers, were under way; and variety tests with green-manuring crops and with fruits and vegetables were made. The varieties of pigeon pea New Era Strain D, Indian, and Dwarf New Era, and a hybrid were retained to serve as a source of future seed supply. Over 600 different lots of pigeon peas were under test. Seventeen varieties of cultivated grasses were grown. The coarser, higher-growing grasses are useful as windbreaks and have value as feed for livestock. In a grazing experiment Rhodes grass (*Chloris gayana*) was found to be the least palatable of the grasses fed to cows but was as readily eaten by horses and mules as are paspalum or Dallis grass (*Paspalum dilatatum*), Bahia grass (*P. notatum*), orchard grass (*Dactylis glomerata*), and Harding grass (*Phalaris tuberosa*). The root crops tested included cassava (2 varieties), edible canna (3 varieties), Hawaii and Japanese dryland taro (20 varieties), arrowroot (*Maranta arundinacea*) (1 variety), and sweetpotatoes (11 varieties). The vegetables under test included lettuce (3 varieties), beans (6 varieties), and garbanzo peas (*Cicer* sp.) (1 variety). The nontree fruits tested included grapes (16 varieties), pohas (*Physalis peruviana*) (2 varieties), and strawberries, tomatoes, blackberries, raspberries, currants, dewberries, loganberries, gooseberries, and pineapples (1 variety each).

A plat of pineapples, 85 by 165 feet, yielded 12,837 pounds of fruit, or at the rate of approximately 18 tons per acre on an elevation (2,160 feet) that 10 years earlier was not considered suitable for successful pineapple growing. Some pineapples were matured about 3 miles from the substation along the mountain side where the elevation is approximately 3,300 feet. The most promising green-manuring crops for pineapples appear to be the blue lupine (*Lupinus azureus*), the jack bean (*Canavali ensiformis*), and the hairy vetch (*Vicia villosa*). The fruit, nut, and coffee trees under test included avocado, strawberry guava, Natal plum or carissa (*Carissa grandiflora*), pomegranate, mango, mulberry, prune, nectarine, lime, orange, jujube, Bartlett pear, Newtown pippin apple, cherimoya, loquat, fig, longan, pecan, almond, Macadamia nut, English walnut, Japanese persimmon, rose apple or malabar-plum (*Caryophyllus jambos*), Brazil cherry, annonas, Red Mexican banana, Chinese banana, and coffee.

The eucalyptus trees planted in 1922 have not only served their original purpose as effective windbreaks but have also furnished sufficient posts for use in repairing fences at the substation. One hundred and fifty eucalyptus posts were used to fence the experimental plats at the higher elevations. Several species of evergreen trees, including the arbor vitae planted in 1928, made some growth during the year.

DISTRIBUTION OF SEEDS AND PLANTS

The general distribution of seeds and plants during the year included 1 packet of seeds and 15 plants of *Meibomia rensoni*, 50 pounds of pigeon-pea seed, 12 pounds of jack-bean seed, 15 pounds of lupine-bean seed, 15 mulberry cuttings, 1 pound of pop-corn seed, 500 edible canna tubers, 1,025 sweetpotato cuttings, 700 strawberry plants, 5,000 Napier and Merker grass cuttings (plus eight 1½-ton truck loads), 100 Uba cane cuttings, 10 banana plants, 26 pounds of field-corn seed, 4 plants and one-fourth of a pound of carissa seed, one-fourth of a pound of strawberry guava seed, 25 avocado seedlings, 2 persimmon seedlings, 2 pounds of *Dolichos lablab* seed, 16 cuttings of cassava, 15 cuttings of figs, 125 cuttings of hibiscus, 5 dewberry plants, 5 downy myrtle plants, 5 thornless blackberry plants, and 10 cuttings of roses.

EXPERIMENTS AT THE HIGHER ELEVATIONS

Four experimental plats at elevations of approximately 3,500, 4,800, 5,500, and 6,400 feet, respectively, were established during the year for the development of strains of pigeon peas and pasture grasses that will succeed in these elevations. Approximately 20,000 acres of pasture land on the slopes of Haleakala alone are maintaining 2,000 steers or cows, at the rate of one animal to 10 acres. There are extensive areas of similar grazing lands on certain other islands of the group. If the forage on these areas can be improved the herd carried there can be greatly increased.

OLINDA

A 4-acre plat was established at Olinda, at an elevation of approximately 3,500 feet. This area is badly infested with gorse and with whin. On March 17, 1931, 61 lots of pigeon-pea seeds were sown. Some of these seeds were obtained from the university farm, some from Pensacola Street station, and some from the Haleakala substation. A number of the lots did not germinate well, but others produced plants that were 8 to 10 inches tall on June 15, 1931. On May 26, 82 lots of pigeon-pea seeds were sown. Some of these came from the same sources as the previously mentioned lots, and some came from the central station in Honolulu and from the United States Department of Agriculture, Washington, D. C. On March 17, 1931, plantings were made of the lupine bean, hairy vetch, garbanzo pea, jack bean, the Scarlet Runner bean, and the Black Mauritius velvetbean. Of these plantings, the lupine bean is making the best showing. On March 17 plantings were also made of Merker grass (a form of *Pennisetum purpureum*), Napier grass, *Paspalum notatum*, and *P. dilatatum*.

UKELELE

At Ukelele, where the elevation is approximately 4,800 feet, a ½-acre plat in the grazing area was fenced for experimental purposes. Fence posts, wire, feed, tools, and other supplies were transported by auto truck to the end of the road at Idlewild and then sent by pack horse or small sled to Ukelele. This plat was in heavy grass sod and required a great deal of work to put it in condition for planting. On May 21, 1931, 87 lots of pigeon-pea seed were planted. These seeds came from the university farm, the Pensacola Street station, the Haleakala substation, and the United States Department of Agriculture. The percentage of germination was about the same as that in the first plantings at Olinda. Pieces of the turf or bunches of Napier grass, orchard grass, molasses grass, kikuyu grass, jaragua grass, *Lolium westerwoldicum*, Rhodes grass, *Paspalum notatum*, *P. dilatatum*, and redtop grass were planted May 21 and started to grow promptly. The average temperature at Ukelele is from 10° to 12° lower than it is at the Haleakala substation.

MOUNTAIN PADDOCK

At Mountain Paddock, where the elevation is approximately 5,500 feet, a ½-acre plat was fenced and on May 20, 1931, 114 lots of pigeon-pea seed were sown. Eighty-seven were duplicates of those planted at Ukelele and at Olinda, and the others came from the Haleakala substation. Grasses of the same species as those planted at Ukelele were sown on May 20. Some hairy vetch was also planted. The percentage of germination was about the same as at Ukelele. The fencing material for the plat was hauled by sled from Idlewild, about 2½ miles distant. Tools and seeds were carried from Ukelele, about 2 miles distant.

PUU NIANIAU

A ½-acre plat of land was fenced at Puu Nianiau, where the elevation is approximately 6,400 feet. This elevation is about as great as is needed for experiment on the island of Maui, because most of the higher lands are included in the National Park boundaries and are not available for grazing. The fencing material for the plat was hauled from Idlewild, about 3½ miles distant. Tools and seed were carried from Ukelele, about 2¼ miles distant. On May 18, 1931, plantings were made of 87 lots of pigeon peas and grasses similar to those tested at the other altitudes. Black Mauritius velvet beans, hairy vetch, lupine beans, Scarlet Runner beans, and garbanzo peas were also planted. The percentage of germination was essentially the same as that at the other places. The experiments at Ukelele, Mountain Paddock, and Puu Nianiau are on land belonging to the Haleakala Ranch Co., whose manager, S. A. Baldwin, is cooperating with the station in making the areas available for experiment. He has also made available the buildings of an old camp at Ukelele for use of substation employees who work at the higher elevations.

REPORT OF THE KONA SUBSTATION

By R. K. Pahau

The 3.28-acre tract on which the Kona substation is located was made available to the station by Executive Order No. 407, dated April 8, 1930. The superintendent's residence and the outbuildings were erected during the summer of 1930, and land clearing preparatory to planting was begun October 22, 1930. Tree planting began December 5, 1930. A number of outlying experiments with coffee, Macadamia-nut trees, akala-berry plants, and miscellaneous fruits were begun largely in cooperation with private coffee planters and ranch owners. While the superintendent keeps in touch as closely as possible with these outlying experiments, each project leader largely directs and oversees the work by making trips from the central station in Honolulu whenever it is necessary. The tropical fruit and nut tree plantings of the horticultural division of the station occupy most of the available land in the 3-acre tract originally set aside for the substation, and efforts are being made to obtain additional adjoining land.

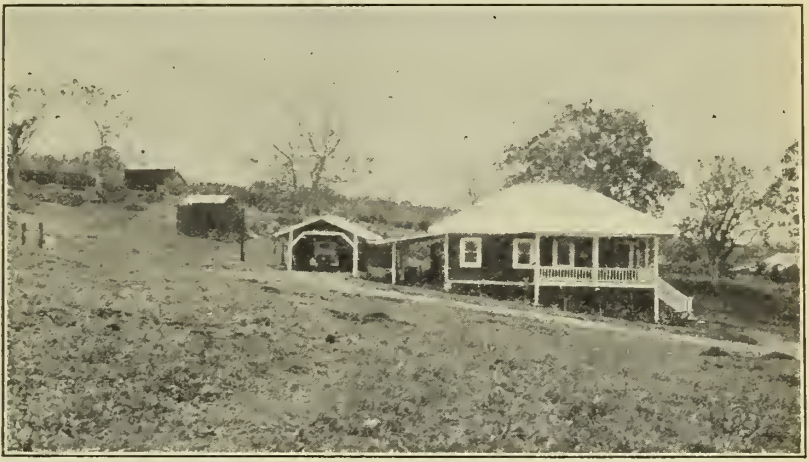

Figure 14.—General view of the Kona substation from the northwest corner of the grounds, April 4, 1931

During the year 729 feet of road was constructed. The newly constructed buildings were inventoried at $4,805, and the stock, land, and equipment at $1,927.55. A set of United States Weather Bureau instruments was installed January 1, 1931. During the six months beginning January 1, 1931, the total rainfall was 24.83 inches. During the three months beginning April 1, 1931, the mean maximum temperature was 75.9° F., the mean minimum temperature was 61.9°, and the mean temperature was 68.9°. The maximum temperature for the same period was 82°, and the minimum temperature was 55°.

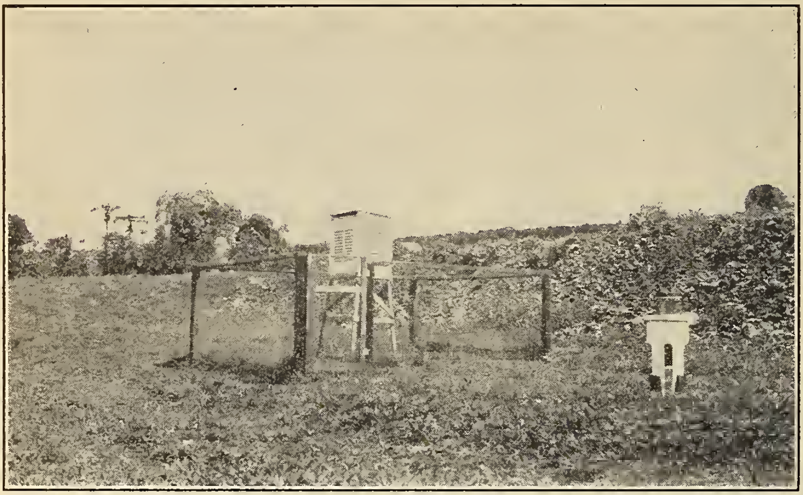

Figure 15.—Meteorological instruments, Kona substation, April 4, 1931

Figure 16.—Laying out the experimental orchard at the Kona substation, April 3, 1931

Plantings made during the year included 32 Macadamia-nut trees of various strains, 23 citrus trees (orange, shaddock, pomelo, and lime), 42 coffee seedling trees (including 15 Hawaiian coffee (*Coffea arabica*) seedlings from Molokai, and 18 seedlings of *C. robusta*), about 200 trees of the Solo variety of papaya and 14 avocado varieties, about 48 poha plants, 56 miscellaneous fruit trees, 1 to 3 each of 33 species and varieties (including breadfruit, fig, and cacao), and 11 varieties of tomato. Various kinds of vegetables were grown as intercrops among the fruit trees.

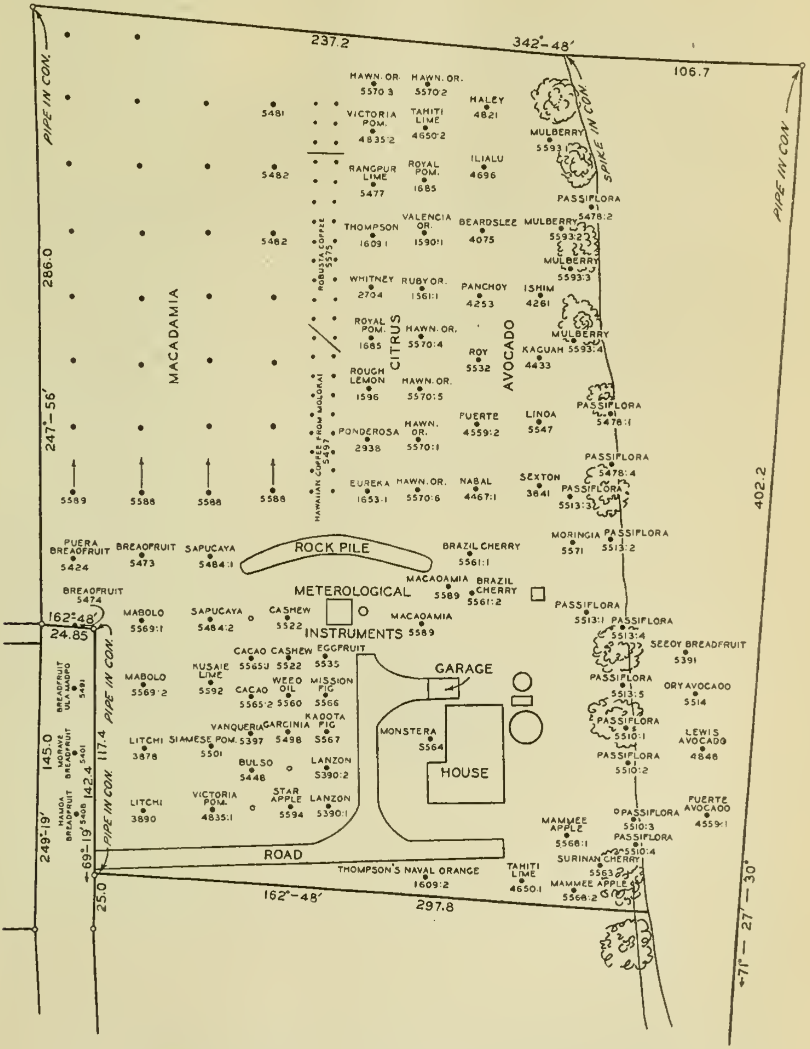

FIGURE 17.—Plan of horticultural plantings, Kona substation, Kealakekua, Hawaii

The livestock of the substation consisted of a flock of 19 Rhode Island Red hens and 2 cockerels, a registered Holstein bull, a cow, a calf, a registered Tamworth sow, and a registered Berkshire boar that is available to the community for breeding.

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